VOCAL ART-SCIENCE

By
FRANK E. MILLER, A.M., M.D.

G. SCHIRMER
NEW YORK

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and Its Application

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WITH A FOREWORD BY

GUSTAV KOBBÉ

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My dear Sir:-

I am sending to you under separate cover, copies of my books, The Voice, Vocal Art-Science and The Banner of Universal Harmony, which I will ask you to place in the Library as a gift from me.

Faithfully yours,

Frank E. Miller

DEDICATED

TO

MISS ADELAIDE GESCHEIDT

THE FIRST EXPONENT OF MILLER VOCAL ART-SCIENCE

IN GRATEFUL RECOGNITION
OF THE SERVICE SHE HAS RENDERED TO
VOCAL ART-SCIENCE
BY THE PRACTICAL AND SUCCESSFUL APPLICATION
OF ITS PRINCIPLES
WITH HER INDIVIDUAL PUPILS AND HER CLASSES
IN VOICE

FOREWORD

Of the making of books there is no end. Especially does this apply to the making of books on voice-culture. As a result, any new book on voice, to command attention, must either have a strong *raison d'être*, or bear the signature of an authority so well known as to make his name a guarantee that the work is a valuable contribution to the literature of the subtlest of all arts.

"Vocal Art-Science" meets both requirements. In matter and plan of presentation it is wholly novel—much of its matter is, in fact, discovery. Dr. Frank E. Miller, its author, long has been recognized as an authority in the art-science of vocal utterance. An eminent American throat specialist, he numbers many famous singers among his patrons. Himself a trained vocalist, he is able to bring to the diagnosis of a singer's condition a sympathetic understanding of temperament and disposition denied those who approach the symptoms from the standpoint of the specialist alone; while in the course of a professional career of thirty-two years he has made a study of over 50,000 speaking and singing voices—a record probably unrivalled in the annals of laryngology.

Dr. Miller's briefer work, "The Voice," is a standard text-book. It professes, however, to be little more than a general survey of the subject; a simple description of the vocal mechanism, structurally and functionally considered; a clear enunciation of the broad principles underlying voice-production, together with much sound advice on hygiene for speakers and singers, and on the higher artistry.

The present work, as its title implies, is a comprehensive study of the voice, a scientific treatise on the art of song; a work in which for the first time, it is believed, the science and the art of vocal utterance are separately developed and then shown in their combined effect upon voice. For the author of "Vocal Art-Science" holds that, for preëminence in singing, neither art nor science alone

suffices, but that art must be achieved through strict adherence to scientific rules. "Vocal Art-Science" is an exposition of the science which underlies the art, and of orderly procedure by which the art is evolved from the science. Its plan of statement, the facts upon which it is based, are discoveries of Dr. Miller. He is the discoverer, the inventor of the science which removes the art involved in the vocal act from the haphazard and replaces the uncertain with the determinate. This book teems with physiological facts; its statements of processes involved in the formation of voice are many. But everything physiological, everything scientific, is offered as an aid to art, not as a substitute for it. Mind is the root, science the stem, art the flower, of "Vocal Art-Science."

Empiricism in teaching voice still has its advocates; nor is Dr. Miller an extremist who would ignore it. His own professional association with the greatest singers of the day has shown him that many great artists are such by intuition; or, as one may say, that they are unconsciously scientific, possessing a special gift by which, as by an inborn critical faculty, they sense the desired effect without perhaps being themselves aware of the processes by which they arrive at it. Dr. Miller is also aware that the great singers of the past were trained by masters who taught empirically. But while the names of these few famous singers live through the ages, what of their contemporaries who failed? For every Farinelli, sent forth by a Porpora, how many thousands upon thousands of vocal failures—tragic voice-wrecks—went down to oblivion? Yet, while the old traditional methods should not be unduly extolled, neither should they be ignored; nor are they in the present book. On the contrary, it is gratefully recognized that through intuition and experience the old masters acquired knowledge of most practical value in the scientific use of parts of the vocal organs. To add immeasurably to this fund of knowledge, to reduce it to a system with absolute formulas both for correct tone-production and for corrective treatment of all forms of misplaced and crippled voices—that is the office of "Vocal Art-Science" in its attitude toward empiricism.

Not for a moment must it be assumed that the author serves up a full vocal course in tablet form, or proposes to substitute mechanical routine for a well-rounded education in vocal art. The formulas he has worked out are, like the multiplication table, scientific time-savers. They are the preparatory steps by which the student approaches the artistic sanctum; the firm foundation on which the artistic structure can be reared. Precise scientific tests are applied to voice, not to place it in a strait-jacket, but to minimize the time usually wasted—and always at the expense of the pupil—in determining a vocal aptitude. By systematizing bodily discipline and adjustments the author increases the time usually wasted—and again at the expense of the pupil—that should be devoted to the pure art of song. Above all, by establishing a codified standard for a true Vocal Art-Science, Dr. Miller has rendered a practical service to the singing world, the value of which cannot be overestimated.

No person has the right to dogmatize about voice, unsupported by scientific explanation according to natural law. In preparing this work Dr. Miller has gone to the very heart of things, to the dawn of creation when voice was not; to the beginning of history, when voice was a manifestation of the Divine. From libraries abroad he has dug out original documents of priceless value to the genuine professor of vocal art. So thorough has he been, that he even organized a search for the famous "Three Pages of Exercises"—with which Maestro Porpora was said to have sent forth his pupil, the world's greatest singer, Farinelli—only to find it a myth. Neither pains nor money have been spared in the attempt to bring the world's stock of knowledge within reach of the humblest student of singing, and to add to it the results of original research, observation and discovery. His system has been constructed with careful heed to the best in the teachings of the master-minds among his contemporaries no less than of those who have preceded him. Nor is it a mere fantasy, a mushroom growth that springs up in a single night and fails on trial. It represents years of patient study not unattended with discouragements. But when it is stated that

more than 200 pupils, in ages ranging from six years to the half-century mark, have been taught according to its principles with results most satisfactory, it may safely be said to have passed the experimental stage, and from positive forms of practical demonstration to have crystalized into a science. By this system of Vocal Art-Science as taught by Miss Adelaide Gescheidt, Dr. Miller has avoided the unfortunate results of the late Dr. James A. Rush, in whose work is recorded the fact that after having lectured for forty years before forty thousand medical and musical authorities, also many more of the laity, he declared his work was in vain because he had not followed the teachings of Baconian logic, i.e., to teach not only through the experience and experiments of others but to add his own. In spite of these wise conclusions Dr. Rush wrote, ten years later, in an "Afterword" to his last great work, "that it was in vain, as he had not left practical living exponents of his ideas of voice-work." In the extremely practical and correct work of the author's only exponent, Miss Adelaide Gescheidt, and her class of over 200 students (who had been operated on for correction of vocal defects), and artists devoted to Vocal Art-Science, the ultimate result desired is not only obtained, but perpetuity for it is assured.

There are few destructive agencies abroad to-day of potency so deadly as the ignorant vocal teacher, the charlatan. But until voice is standardized it is impossible to inaugurate a campaign against these enemies of mankind. Before voice was analyzed and registered automatically it was not understood. Voice-analysis and registry must be universally accepted, or the divinest gift bestowed on man is at the mercy of the charlatan and can claim no protection from the law. Dr. Miller's invention, the vocometer, forms an absolute record, measuring the head and neck in order to estimate vocal content and capacity, showing on the basis of such measurements what can be expected of a voice in compass and quality with its power, limits and possibilities according to sex and age, while noting in what respects it deviates from the normal standard. From such a record the teacher is enabled to work unerringly in voice-building, on lines both corrective and constructive.

While in Vocal Art-Science much is expressed mechanically, and while mechanism is employed in its tests, it is not to be understood that mechanical devices enter into its teachings. The individual is trained almost entirely through vocalization, by definite muscular combinations worked out in a system of self-governing bodily units or autonomies. Voice, as Dr. Miller points out, is the child of brain and body, and with every muscle flexible, all muscular action coördinated under the direction of the brain, the human automaton—better, perhaps, the physical automaton—becomes a well-nigh perfect instrument for the expression of the soul.

As radical an innovation in voice-teaching as is his system of bodily autonomies will be found in the author's theory of pyramids as applied to the human voice. By the pyramido-prismatic Voice Chart he proves conclusively that voice is at all times the product of prismatic force, operating in the human body through the atmosphere, so as to produce the balance of power, resonance and pitch that forms the singing tone. These three essentials of voice, issuing in spiral tone-thrusts from nose and mouth, with alphabetic modifications, constitute (he shows) the perfect diction and expression of speaker and singer when directed by the brain and colored by the soul.

A new discovery in science teaches that within the human body is a chain of five organs in a system designed to transform potential or latent energy into heat and motion. This, the kinetic chain, seems to stand as a direct corroboration of the Miller theory of the five autonomies by which atmosphere is converted into voice. Muscular coördination, a natural system consisting of a chain of organs to be employed automatically when the brain invokes the use of song, this is a basic principle of "Vocal Art-Science." Mental audition, the act by which the inner ear gauges and adjusts the voice in advance of the outer ear—too little insisted on by the great majority of teachers, too little understood by the majority of pupils—is a matter on which "Vocal Art-Science" also lays due emphasis. That the would-be singer may become his own master, audience, and critic, all in one, is a result to be

expected with no uncertainty, assuming adherence to the principles enunciated, and a conscientious observance of the discipline prescribed in this work.

Self-criticism, without self-consciousness—when a student has achieved this, he may know himself to be in a fair way to success.

Summing up, let us say that the Miller Vocal Art-Science is based on the natural laws that govern normal tone-emission. It asserts, with scientific proof, that this depends upon the perfect coördination of all the muscles of the body, external as well as those hidden in the recesses of the frame. Moreover, because the muscles are treated from the standpoint of their nerve-supply, direct from the brain, a part of the subject that seems hopelessly physiological is tinged with the finer colors of the psychical.

The book establishes a theory of the pyramido-prismatic forces at work within us, analogous to those that engender light and energy, to give vocal utterance to the message of the soul. Through an understanding of the five vocal units or autonomies, it teaches how to turn the body into an automaton, supple, poised, obedient to the dictates of the mind. By correlating the five centres of force involved in voice-production into one supreme centre, at the solar plexus, it leads vocal art to the threshold of the kingdom of psychology. By a wise direction of energy it saves the pupil profitless labor; and while it definitely repudiates the notion that there is any royal road to learning, it simplifies the mechanism of vocal technique so that the student may not be hampered in his æsthetic expression by cumbersome machinery. Out of the chaos in which voice-teaching has long been involved it has brought order and an efficient organization based on the great fundamentals of life.

It has been found necessary for more definite detail and technical information, also to save time for the reader (in contemplation of new and mooted points that would not be conducive to the purpose of this work), to add an ample and complete Index, Glossary, Addenda and Bibliography. The author, by a system of Phonocraft and voice-craft, gratefully acknowledges many suggestions

drawn from the works in this list, which gave constructive materials for this work.

The true student remains ever a student, an investigator. The finer the artistic achievement, the more surely he realizes how much there is still for him to learn. The fuller the measure of the world's applause that crowns his effort, the more watchful does he grow, lest success shall spell stagnation; the more zealous to eliminate his faults—for who is faultless?—and to approach that perfection by which the human voice is indeed the instrument of the Divine. It is not only for these, the great; but also for the others, the brave of spirit, who have their way to make through trial and privation, that Dr. Miller has written his illuminating work, the new "Vocal Art-Science," in my opinion an epoch-making book.

I firmly believe that it will be possible some day to obtain a real standard for voice by means of various apparatus already in use but not yet sufficiently perfected for the purpose.

"If," Dr. Miller has said to me on this very point, "with the perfected Oscillograph and the Telegraphone, we can record and reproduce, at will, all the tones of the human voice with all its ramifications of timbre and overtone; if we can construct scales of perfect tones, such as would be sung by a Melba or a Caruso; if we can combine with this the kinetoscopic representations of the artists singing these tones and the X-ray photograph when this has been done—then, it seems, the millenium of Vocal Art-Science will be at hand, for a *real* standard for voice-production will have been established."

GUSTAV KOBBÉ.

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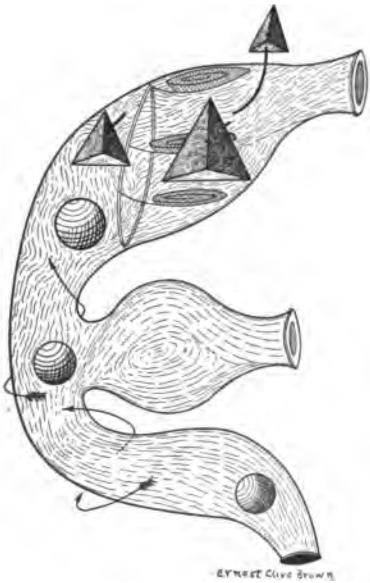
VOCAL ART-SCIENCE



Glass Resonator.

The above cut illustrates a glass resonator, modeled several years ago by the author after the vocal canal of M. Jean de Reszké, used to demonstrate the direction and spiral course taken by sound-waves for the pitch of middle A through a smoke medium.

The reconstruction shows three cavities, nasal, oral and laryngeal, in relation to each other and to the various portions of the pharynx.

The area posterior to the ring demonstrates the position of the pharyngeal dome with respect to the turbinate bones. The small pyramids assume the rôle of the shock absorbing sinuses, with their canals terminating in the nasal cavity. The three shaded circles are the sphincteric apertures (Epiglottis, Tongue and Palate) through which glass slides are thrust to reproduce their various actions.

A model similar to the above was constructed after the vocal canal of Mme. Marcella Sembrich during the same year.

Owing to their efficiency for demonstrative work many new models have since been constructed and from their principles have evolved several interesting mechanical devices.

To avoid complexity, all the sinuses and turbinated bodies have not been shown.

VOCAL ART-SCIENCE

CHAPTER I

Introductory Remarks

Voice, the Heaven-bestowed, is the mirror of the soul. Speech, which is voice modified and adjusted, is the great articulator of all human relations and social life. Song, which is voice developed according to certain laws, and wedded to poetic speech, is at once the most human of arts and the most divine.

Voice the greatest medium of personal expression.

In no way can personal expression find a medium so effective as through the voice, whether in the actor's interpretation of a great dramatist, a singer's rendering of a glorious composition, a speaker's enunciation of the moral law, or in the intercourse of daily life.

Yet, with the very burden of humanity resting on it, the science on which the art of speech and song, in common with all arts, is based, has been too long neglected. Teaching synthetically and intelligently is conspicuous by its rarity, while methods faulty and meretricious are generally prevalent in schools and universities, especially in schools and universities which justly boast of their courses in scientific farming, practical draughtsmanship, pedagogy and domestic science.

Good vocal teaching all too rare.

Faulty methods in universities and schools.

The art of speech and the art of song are, up to a certain point, essentially the same, being the product of laws physical, mechanical, and at times mathematical—laws which, consciously or unconsciously, must be employed in its exercise as surely as an observance of the laws, governing the calculation of bridge-stress, the perfection of a picture, the balance of an aeroplane, or the voluntary act of conception through forces operating automatically in the production of the child, all of which forces are by nature a necessity.

Wasted expenditure on prevailing methods.

Does any one exclaim, "But all this is understood. We already teach voice-production, and the art of speech and song, throughout the country in all its common schools. It is a matter in which we spare no expense!" then of such I ask, "Where are the results? Why the unrefined accent, the nasal twang, that far and wide mar voices by nature not unmusical?" That no expense is spared I am fully prepared to grant, but that the expenditure is well invested I emphatically deny.

Again another bids me, "Look at the conservatories. Think of the number of well-known teachers engaged in this uplifting work." And again I challenge: "Show me the results. Where in large numbers are the native singers of concert, choir, and opera, who do not depend on some adventitious factor, such as personal vogue or advertisement, for their popularity? Where are the graduates of these institutions, the finished products of these private teachers, who should in large numbers be honestly entitled to take their stand in the front rank, through the exercise of a good organ faultlessly trained?" True indeed is it that, in more ways than one, many well-known professors in all our large cities are engaged in filling their own coffers at their pupils' expense.

Requirements by which to test excellence of teaching.

Wanted, good tone, freely emitted, with clear enunciation. When all the pupils put forth by any teacher —not only the best or show pupils, but all—when such, infallibly, conform to these requirements, then one may rest assured that there has been nothing factitious or haphazard in the vocal discipline to which they have been subjected, but that it has been studied out, systematized and based on natural law. To such teachers—all too few!—I pay my homage.

Value of foreign study discussed.

Is this annual pilgrimage of young vocal aspirants who can afford it, and of those who cannot without assuming a heavy debt or obligation, worth the old-world methods and the *cachet* of a foreign name? While in some respects the glories are departing from France and Italy, and their famous teachers of vocal art are fast becoming memories, the traditions of their schools still linger. In countries where a higher standard of musical excellence is the popular

heritage, the methods of voice-production, though by no means faultless, may still be considered superior to our own.

Vocal excellence within reach of all.

Great teachers and great artists there have always been and always will be, to the end of time. To show to what degree of perfection vocal art can attain, the world will never lack a Garcia, a Melba, or a Caruso. The supreme gift that makes singers royal in their several domains will always remain a something awarded by the favor of the gods, the incalculable thing. But the greatness of Garcia, founded on exact science as applied to vocal art, grows greater every day and it is within the grasp of all painstaking teachers to emulate; while the mechanism, with not a little of the subtle power of inspiration by which the golden tones of the famous singers are produced, can be acquired.

General musical awakening.

Never was there a day in our country's history when the musical awakening was more pronounced than at present. This is evidenced by the clubs, societies and operatic ventures springing into life on every side. Nor was there a day when our students realized more keenly the folly of being forced to seek abroad what, in its initial stages, should be better learned at home.

From all parts of the land comes the cry, Give me knowledge! Show me the truth! Help me to a definite procedure in the use of my voice in the Divine Art of Speech and Song, that I may bring out the best within me, and thereby enrich my own life as well as that of others, and increase my service to the Creator of all things!

Whether opera, oratorio, concert, vaudeville, choir, pulpit, lecture-platform or the home be the chosen field, the desire is the same, and the demand incessant for some plan not limited to school or special teacher, but for one that, being founded on basic principles, must infallibly command universal recognition and compel adoption.

Old masters taught by sound principles.

The great teachers of Italy taught by methods that modern research endorses as grounded on an understanding of physiology. Their methods were often empirical rather than synthetic, but it is to be noted that they had opportunities for testing results that do not obtain under

the conditions of to-day. The old classic traditional methods handed down from generation to generation always underwent some modification due to observations and discoveries; and whatever has persisted through centuries of change remains as a standard for to-day, and is based on permanent principles whether consciously applied or not. This is as certain as that the law of gravitation was in operation before ever a Newton was born to formulate it. As Salvatore Marchesi puts it, "We cannot throw away all that constitutes the inheritance of the ages, but must use the new ideas to complete and perfect the old." The old masters who were great masters not only taught on principles now recognized as physiologically sound, but they also aimed for a standard tone. It is for us to-day, with our great country and wealth of material for observation, with funds generally and generously available for research, with new apparatus to test, corroborate and record, and with the wonderful discoveries that science recently advancing by gigantic strides has opened up to us, to illuminate the wisdom of the past by the knowledge of the present, all of which has been actually accomplished and recorded in the annals of this Vocal Art-Science.

New discoveries used to perfect old ideas.

Why is it so difficult to get any twenty persons interested in the matter to agree as to what is good or bad for each voice, so far as tone-production is concerned? Is not this lack of unanimity largely due to the wide divergences of opinion as to how tone itself is produced?—divergences attributable, as I think, to the fact that so far throat specialists, physicists, teachers and singers, have seldom worked together; each investigating independently, regardless of important factors found by others. To this lack of coöperation may, in turn, be attributed the inaccuracies with which laryngo-pharyngeal observations are replete, and which have rendered it impossible for conclusions of general value to be deduced. To my mind it is indispensable that thousands of individual cases should be presented to give scope for the widest observation in order to furnish a solid foundation of fact on which we all can take our stand, working, each on his own lines, yet in general harmony, toward a common goal.

Present divergences of opinion as to methods.

Lack of coöperation among investigators cause of poor results.

I hold that, while the actual production of voice is an art, voice-training and examination may be made more or less scientific by means of measuring and recording devices which permit exact study and analysis of tone. So far as I know at present there is no really scientific method of such procedure. Wave-analysis, as at present carried out, and tone-examination by resonators, capsules, and rotating mirrors, are at best unsatisfactory, nor does phonographic reproduction furnish an exact reproduction of voice. Probably no device depending on a mechanically operated vibrator will ever succeed in precisely paralleling the human organ.

Unsatisfactory results in present methods of tone-analysis.

The scheme employed in Paris of locking up the records of famous singers for future reference is undoubtedly useful for purposes of comparison, but, considering the errors incident to mechanical reproductions, they would hardly serve as models on which to found a standard tone. Examining the apparatus in the Carnegie Institute I find that, in addition to indistinctness of tone from the imperfect transmission of the sound-waves, allowance must be made for large loss in overtones. The stylette condition of wax impression, the tube through which sounds are emitted, the disk vibrations, and the character of the receiver, all have to be taken into consideration. Large sums have been spent by this foundation for exact and delicate instruments for the production of graphic forms of the human voice. Yet, after careful examination of them, I find that they must be rejected, too many errors having been allowed for. As an instance of this, of the thirteen high C's produced at my own expense by the most sensitive instrument in their possession, none stood the test. After carefully looking over the disk from which these were taken, and then reducing the pitch from C to A, it became apparent that what was heard at the rate of 512 vibrations a second, when brought down to 426⅔ (A's rate of vibration), was most unmusical and therefore obviously useless as a standard tone.

Imperfections of mechanical records.

None the less, since tone is the foundation of all singing, and as the character of tone is the very thing for which our artists are generally criticized, it naturally follows that

Standard pitch adopted fororchestra; equally necessary for voice.

a scientific system of voice-building should be formulated. But before the study of voice can be reduced to a science, a standard or ideal tone must positively be established. A standard pitch for orchestra was recognized as absolutely necessary, in order that every combination of musical instruments might produce harmonious results. By mechanical means this was achieved without great difficulty, and in a manner nearly perfect. Surely it is of no less importance that the human organ should also be brought within the scope of a universally adopted test. As the perfect tone is formed by a combination of vibrations, there is no reason why it should not be standardized.

Idea of mechanical tone measurer abandoned.

As long ago as 1891 I stated this necessity for a standard tone, and at the same time had the idea of constructing a voice-measure, tone-tester—a phonometer, if you please. This was to consist of a combination of phonograph and mechanical reproduction of the registration of vocal sounds so arranged as to present a standard tone, while able to measure and compare for all time every voice in the world. After much deliberation and a thorough discussion of the subject, the project was abandoned, one definite conclusion having been reached—that for the present the only criterion is the ear of the teacher, the judgment of the tried and experienced maestro.

Ear of trained teacher the sole criterion owing to idiosyncrasies of overtone.

To-day it is generally admitted that a tone consists of a fundamental, plus a series of overtones, each present in and sounding with the fundamental, though with different degrees of volume, and with organic modifications in different voices.

Character, timbre and quality are imparted to the fundamental by these idiosyncrasies of overtone, therefore it would be virtually impossible for two voices singing the same tone to be compared without going into physical measurements of sound-waves, while the trained hearing can infallibly appraise results at the moment of utterance.

Records of great singers as templates for sound-waves produced by pupils.

Granting that Melba and Caruso are the highest exponents to-day of tone-production in woman and man, correct records of the work of these artists would furnish exact templates or models with which to compare records of sound-waves produced by vocal students. Variations

could thus be ascertained, and corrections made accordingly, while further records taken from time to time would mark progress until the maximum of excellence had been secured.

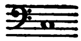
All measurements only approximations to truth.

The measurements of time and space by the most delicate instruments, that have engaged the intelligence of the ages, are but an approximation of the truth, and even the period of the sun's revolution in the ecliptic, and that of the earth about the sun, are not absolutely determined, yet so infinitesimal is the degree of error for which allowance must be made, that, notwithstanding, a fixed standard has been adopted and prevails universally. In like manner let us strive for a world-tone, and by practical mechanical illustrations, so far as these can demonstrate how tone is produced, place the possibility of acquisition at the public service.

Music cosmic, natural.

Music is cosmic. The voice of nature, whether heard in the thunder of Niagara or the hum of a bee, seems attuned somewhere about the key of F. So with our model voices, their natural key lies within their normally best tones, which range from F to C. Following this lead, we accordingly predict that our standard will be found, a statement that experiment invariably verifies. Experiment, no matter how often repeated, or on how many subjects, invariably sets the natural pitch at C, as the normal human note.

C the natural human note

If one uses the tone  (128) as fundamental resonator, and builds on this a series of overtones, the result will be as follows: That its first overtone is at 256, an octave higher; that its next overtone is at 384, a twelfth higher; that its next overtone is at c^2 512, the double-octave above, with the following overtone at e^2, or 640; then g^2, or 768; then $b^2\flat$, or 912, until we come to c^3 1024. Beyond this they become inharmonic; that is, in the order of c^3 1024 to d^3 1152, or Do to Re, a combination that the ear naturally rejects. Now this was a splendid discovery, and although on a purely arbitrary basis, it nevertheless established nature's pitch, which must be taken as our universal standard.

This demonstration is within the reach of every one. By using tuning-forks with the mouth for resonator the human overtones respond to c^1 256 as to no other fundamental.

Compass of voice mathematically demonstrated.

This understood and assented to, it logically follows that the human voice is limited from the C 64 below for bass voices, to c^3 1024 above for soprano voices, each kind having its special compass, whether these are tenor, contralto, or the intermediary classifications. Every tone above c^3 1024 then will be a fundamental, corresponding to the harmonics of the violin in its extreme high range, or to the high tones of a piano, or to the flute throughout its range, the voice-producing mechanism bearing this out.

By natural law this standardization of pitch for the male voice is c^1 256; while for that of the female it is at c^2 512, an octave higher, according to the law of octaves in pipes,.or tubes stopped and unstopped.

When the overtones become inharmonic the voice is not musical, because music is the science of combining tones in melodic, rhythmic and harmonic order so as to excite the emotions or convey intellectual appeal.

Tone-production a mechanical operation according to natural law.

With our standard pitch established, with records of great artists as our models for comparison, our next question concerns itself with the actual producing of tone. What is tone-production? The very name indicates that it is sound generated by mechanism of some kind. Obviously, then, this mechanism must be correctly operated to ensure correct results; or, in other words, a normal standard tone.

What is the mechanism requisitioned in the production of the human voice? Is it something mystical, so that one person may be trained in one way and another by methods radically different? Is nature definite or indefinite, irresponsible or law-abiding? To those familiar with anatomy and physiology there is but one answer: Nature intends tone to be produced by a precise and normal balance of all the parts involved. And as troubles manifest themselves in other organs of the body when maladjusted, just so it is with voice-producing agents.

Does not this point to the conclusion that all who profess to train the voice should, to the last detail, thoroughly understand the mechanism of the larynx? When we seek medical treatment we are guided in our selection of a physician by the reputation for knowledge, understanding and experience, proved by successful results, and authenticated by special preparation. Should we be less careful in our choice of a vocal teacher? I hold that the master of tone-production should know his subject with such finality that even without looking at the singer, but simply by the sound of the voice, he should be able to diagnose the case and determine the trouble, decide what muscles have been interfered with, to render the tone faulty, and so be in a position to prescribe corrective exercises.

Care in choice of teacher as essential as in choice of physician.

The ear as true diagnostician.

It is not necessary for the average student to have a knowledge of the structure and function of the vocal organs, except in a general way, but the master must be an adept in this respect, or be unworthy of the name.

By this time my readers will have gathered that Vocal Art-Science presents nothing of a subversive nature; on the contrary, it is a recognition of the eternal verities. It is based, not on the unsupported theories of faddists, but on the natural laws of cause and effect, founded on precise observation, and coördinated systematically. Nor is it the purpose of this work to discredit the empiricist, or to deride any honest method or belief. Recognizing that the old masters unconsciously evolved scientific principles and an ideal tone, it aims to revive what of their teachings has been lost, and to enrich the old ideas by the new. Without regard to special school or system it seeks to place actual facts in anatomy, physiology, pedagogy and psychology at the disposal of all, so that from chaos order may spring, and a correct voice-synthesis be obtained.

What Vocal Art-Science is.

Based on natural facts, and not merely on man's assumption, it deals with the laws of cause and effect; classifying voice as the result of muscle contraction, under the stimulus of nerves of motion, nutrition, and inhibition, working in automatism, in a series of units, the common focal point of which will be found to coincide with the very heart and centre of vocal existence.

Voice produced by muscle contractions with psychic attributes.

On these grounds it insists that voice must be studied, primarily, from the standpoint of mechanism, and that on a perfectly controlled mechanism the inspirational side of art depends for its expression, as well as for the indefinable quality that reflects itself from the artist on the audience, and realizes for him the fullest measure of personal possibility.

It places the ear as the controlling sensory centre, and requires of the teacher such expert use in diagnosing faulty tone, simply by the sense of hearing, that any mechanical device can only corroborate his findings.

In a single treatise it would be impossible to give a detailed plan of voice-production applicable to every individual singer, because of the many different conditions existing in each case of tonal effort. But what can be done is to give the correct position of head and larynx, the special organs of voice, including its factor of resonance, and the exact action of the larynx, the momentic source of voice, as these appear to the careful observer, unaided by the microscope or a course in the dissecting room.

Nine muscle-sets to be studied in voice-producing.

Concerned with voice-production there are nine muscle-sets, each with its independent nerve-supply; the muscle-sets and nerve-supply illustrating, in their coöperation, the close union of physiology and psychology in muscular action, which is determined by the mind, working through innervation on the muscles. Each of the nine muscle-sets is capable of upsetting the voice-mechanism; yet the muscle-sets never appear to have been studied, for voice-production, in the light of that most important factor, their nerve-supply. In this light they have been investigated by Vocal Art-Science, in which respect it is a wholly new departure from methods now in use.

Nerve-supply the new element introduced.

Vocal Art-Science insists that exercises for the development of voice shall be prescribed only by some person who has studied voice-mechanism in detail; one who, for instance, for a pinch in the voice, the result of overworking the hyo-glossi, would not seek to overcome it with exercises of the digastric, or vice versa. Also it reiterates that its exercises for voice-development must be under-

taken by one whose musical knowledge is capable of determining whether the vocal poises are absolutely correct; for if these exercises are attempted with improper tone-emission or focus they are worse than useless, for the reason that no fault ever is cured by practising it.

The hypnotic voice, and what it proves.

While not advocating hypnotism in voice-cultivation, yet as it can present cases of fine vocalization from average, normal, non-musical persons under hypnotic influence, it deduces that every one can in some measure be taught to sing. Moreover, as the subject under hypnotic influence usually reproduces the record of some great singer, this suggests that only perfect models be held up for imitation.

The oscillograph.

The new science in Vocal Art holds forth hope that before long musical notes may be caught at correct pitch, with proper instrumentation, and with all their psychological embellishments, on the telegraphone, or some other correct and approved recorder, which records overtones as well as fundamentals, and thence transcribed by the oscillograph, the only device that can register the graphic forms of sound-waves including the klang-tint, the tonal color by which beauty of voice is determined. With scales built from notes so captured, with kinetoscope representations and skiagraphs of great artists producing these perfect notes, perfect models in every respect will be assured.

Endorsement of Vocal Art-Science.

Vocal Art-Science states, not without pride, that it is endorsed by the foremost singers. It offers the advantage that the student's voice is put into working order immediately. It promises that, after years of the accurate vocalization enjoined by it, the success of the voice under cultivation is assured, with effortless production of pure and perfect tone.

Early training through habits advised.

It advises the earliest attention to voice-training, not only by individual and standard set exercises, but also by presenting good models of speech and song to the young, by the avoidance of bad habits, and by that careful cultivation of clear enunciation that marks the well-trained child.

Finally, Vocal Art-Science invites coöperation and discussion from all interested in good results on the lines of

voice. It calls for frequent conferences of throat-specialists, teachers, singers and speakers. It suggests a system of marking by which at such gatherings comparisons can be made most effectually, and the calculable factors in tone-production scientifically registered with allowance for personal equation, temperament, and the qualities of individuality.

Based on the laws of nature and not on mere assumption, Vocal Art-Science holds that voice from the standpoint of evolution depends on its resonators, and that these to the number of twenty-four must be trained and correlated before initial tone can have full reinforcement.

Analogies and deductions.

Also it presents a few analogies between the phenomena of light, energy, sound and graphic form, with the general deduction that not only is voice cosmic, but that song is merely another guise for these material activities, itself a manifestation of light and form, a color-interpretation of the divine nature which is none the less divine for being susceptible of scientific analysis—indeed, for that very reason all the more surely divine.

A singer myself before becoming a physician, and after thirty-two years of practical, specialized work, not to speak of association with leading investigators and great artists, I feel that I have at least a fair idea of what does and does not constitute good singing. Accordingly, to all interested in good work on the lines of voice I offer the result of my observations in the form of an attempt at a true voice-synthesis, a Vocal Art-Science.

CHAPTER II

The Evolution of Voice

Voice is first, last, and at all times, automatic, consisting of detonations from a sphincteric aperture.

From the first, all natural processes were based on the principle of automatism; that is to say, nature, as we understand it, manifests itself in forms of motion, carried on by self-acting machinery.

Let us examine the application of this to voice-production by reviewing a few simple facts. Biology teaches us that the vital cell presents two fundamental aspects; one the power of taking in substance; the other the power of ejecting substance. Also there is an inflow and an outflow of energy; in other words, an afferent mode and an efferent. These two aspects form the foundation of the two kinds of nervous systems found in the composite organism of man: namely, the cerebro-spinal, and the ganglionic or sympathetic. The former governs the voluntary muscles of the body. At its dictates they assume relations and positions. It controls the actions of our conscious life. Under the sympathetic nervous system the involuntary muscles take entire charge of all bodily functions, all vital processes.

The voluntary muscles, dominated by the brain, are structurally external, while the involuntary are usually hidden in the deep recesses of the organism, interpenetrating the entire frame. Stiffness or suppleness is the measure of the condition of the exterior muscles, whereas our psychic energies, our rhythmic reactions, rest upon the sympathetic.

In point of time the ganglionic system takes precedence over the cerebro-spinal, being the first to appear in the embryo and that from which, indeed, all others virtually are formed. The various autonomies, functions, tissues, structures, and processes, emanate from this psycho-physiological life-centre. The vital point where the pas-

sional nature comes into contact with the sensuous is known to philosophers as the focal point of life and death.

Even as it presided over the beginning of life-impulses, so does this sympathetic nerve-system control the wear and tear of the organism, all body-building and repairing being under its supervision. Not only is it the chemist, but also the laboratory of the human structure. William Hanna Thompson tells us that "the Sympathetic actually makes drugs or true medicine, whose presence in the blood is essential to life." In animals, so this author states, the extirpation of the solar plexus, the seat of the sympathetic nervous system, causes death, preceded by profuse "rice and water" discharges and accompanied by other symptoms resembling Asiatic cholera. Working incessantly, the sympathetic nervous system sustains the whole structure; were its activities to cease, the body could do nothing; the entire fabric would be wiped from the face of nature. As it was first at birth, so it is last at death.

The cerebro-spinal system belongs to organic man, being responsible for the activity of all senses, all mental perception, everything, in fact, that deals with the outer, conscious life. With its pole of power at the brain and with the spinal cord, and tracts extending to every part of the body, it deals with an exterior world, responding to light, color and tone. Man has developed more strongly along the lines of conscious activities, consequently he is a one-sided being, viewing most things from an objective standpoint. Not until he has failed repeatedly from pure dependence on his brain, does man at last turn to other sources of power and inspiration—to the subconscious self; a source of power and inspiration that, living as it does so near to the realm of things unseen, holds the key to the spiritual life, yet, notwithstanding, must ever use the physical as the vehicle for its expression.

In Vocal Art-Science the Great Sympathetic system gives soul and spirit to speech and song. Viewed from this life-centre it proclaims that all directions, as to the management of the voice, must be subsidiary to the expression of feeling.

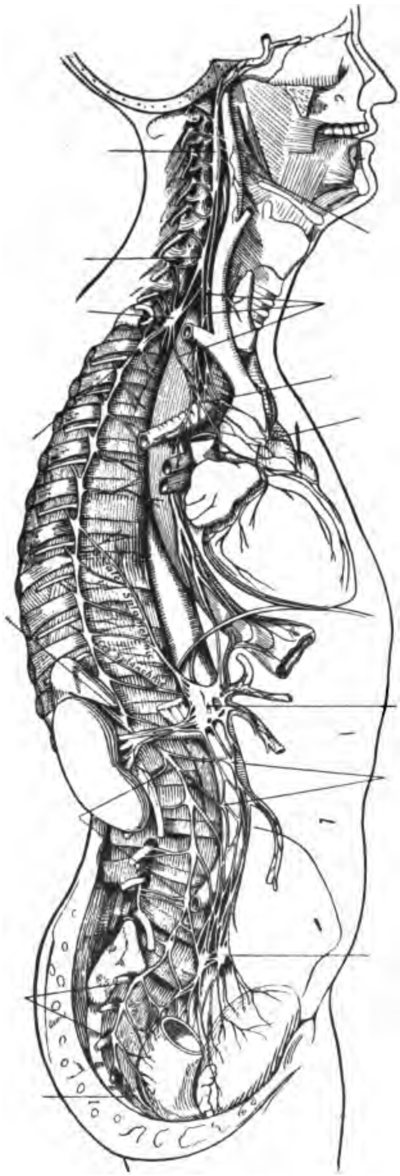


Fig. 1. Solar Plexus.

When Joseph Jefferson, the famous Rip Van Winkle, was asked by a conservatory student, "Is it necessary to feel keenly within one's own sympathetic system that emotion which one is about to convey to another in song?" he answered, "A warm heart and a cool head, my child, so that the artistic rendition shall not be marred."

Pure art is not mechanical; pure art is not physical, but metaphysical; pure art is inspiration. All art must have its origin in the soul. Vocal Art deals essentially with this aspect of tone-production, the intuitional, emotional, affectional and passional features of speech and song. It is under the domain of the primary or rhythmic system of the human organism, close to the very foundation of life. How shall we arrive at its lawful but unfettered expression? There is but one way: "The perfection of an art consists in the employment of a comprehensive system of laws, commensurate to every purpose within its scope, but concealed from the eye of the spectator; a comprehensive system of laws producing efforts which seem to flow spontaneously as though uncontrolled by the influence of these very laws—efforts which are equally excellent whether regarded individually or in reference to the proposed result!" In other words, there are definite laws by which the outer being can express and convey the message of the inner; laws so clearly established that by obeying them the highest art will be attained, namely, that of concealing art, and presenting a result with such perfection of automatism as to seem unstudied, the child of inspiration, in form no less than in spirit.

The formulation of these laws by which art is enabled to find expression for the message of the soul lies in the province of the scientist. Vocal Art-Science deals with these laws from the standpoint of muscle-actions and control, both voluntary and involuntary, in their relation to the structures and functions of the organism; further, it deals with the laws of sound, physically and mathematically recorded, which are involved in tone-production.

Combining the two, Vocal Art and Vocal Science, into one system, that of Vocal Art-Science, this naturally insists, as the nomenclature would imply, on the exact cor-

relation between the physical and psychic in tone-production—the scientific or mechanical on one hand, and the artistic or inspirational on the other—and seeks to establish a union that exists between these apparent opposites.

In this harmony, through the perfect realization of coöperation between the activities of the cerebro-spinal and sympathetic nervous systems, it is believed will be found an explanation of genius.

Such coöperation, bridging the chasm between the two poles of power, joining positive pole with negative, creates in the artist selfhood of the highest order, an at-one-ment of the entire being, through the controlled intellectual perceptions, diversified expressions, combined with the adjustment of normal, emotional, and spiritual forces.

It is unquestionably our want of knowledge, knowledge of the world about us in its true meaning, and knowledge of the forces locked within us, that forms the obstacle between our ambitions and hopes and the full realization of them. It is only as we develop a higher standard of scientific and artistic training that we can begin to comprehend the marvellous agency existing between the immaterial principle and the physical operations of the mechanism, resulting in tonal beauty.

Wordsworth writes, "Enter into the soul of things!" So long as science was engaged only in investigating natural sequences and phenomena, it failed to arrive at the laws of causation. Formerly, science insisted that there were only two things in the universe: matter and force. To-day, with the discovery of radium, matter is eliminated, or rather has become fluidic at the approach of thought. What still appears as matter is but stationary force, or, in other words, lazy electricity. Mme. Curie, following in the footsteps of her husband, reached the soul of things when at the core of a substance she found radio-active force. Tesla reached the soul of things when he discovered that the behavior of energy depends on the frequency to which the fluidic stationary force is subjected. And in the same way every great discovery is but a dim prophecy of greater things yet to be revealed in

the life of man. Even as the telescope added to the natural powers of eyesight, so clairvoyance develops the power to penetrate the subtler regions of thought and spirit. The materialism of a quarter of a century ago, that great wave of agnosticism that swept over the intellectual world, has receded before the new understanding of the constitution of matter and the nature of energy. How can doubt exist in the presence of a speck of radium, so small as easily to drop through the eye of a needle, yet its radiations emanate at a velocity forty thousand times greater than that of a bullet in flight? When one realizes that heat, light and energy are produced night and day by such a speck, without appreciable expenditure of substance, is it so difficult to believe that we are on the borderland of fruitions greater than all we have dared to dream?

So through an understanding of the dual nature does Vocal Art-Science seek to bring the earnest student nearer the soul of things, believing,

> Man as yet is being made, and, ere the crowning Age of Ages,
> Shall not æon and æon pass and touch him into shape?

We are the results of the operations of unnumbered ages, the sum and substance of evolutionary forces of countless periods of time. Man is the end toward which all animal creation has tended. As Dr. Oken said, "Man is the sum total of all the animals!" Man is more than this: He is the product of the workings of stellar and solar worlds, and is closely associated with and related to the universe to which he belongs. Carlyle truly remarked, "On the hardest adamant some footprints of us are stamped in, and the last rear of the host will read traces of the earliest van." In our quest for initial voice, however, we must retrace the steps of evolutionary progress, until the day of the first man and woman are left far behind, and we find ourselves as near as we may approach to the beginning of things, in the rude workshop of the world. Then, as now, creation was all motion, though we do not understand it; all we know is what we see and hear, the objective world. Here in the ooze of some pool we come upon a tiny mass of floating protoplasm, a group of cell

life, the progenitor of the primordial globule and the ancestor of the amœba. One such form, from the readiness with which it changes its contours, has been called the Proteus. This may be regarded as an animalcule whose sole occupation is self-nutrition, carried on by the usual process of intake, digestion, and outgo. Of these the first is achieved by surrounding the desired particle with its filmy mass, and absorbing this into its principal cell where the life-activity is carried on. For the waste, or indigestible substance, an outlet must be found, and this is formed by an aperture capable of enlarging or diminishing itself at need. In higher forms where muscular tissue is present this would be a sphincter (derived from the Greek verb "to bind"), but in this case it may be better described as a contractile vacuole. Its action is automatic. Gas, when expelled from its single chamber of life-activity, causes a detonation, *and this is the initial manifestation of sound in organic life.*

Amphibia: The salamander shows the first resonator.

Rising a step in creation's scale, we find the Salamander as the next sound-producer. This is an amphibian, equipped with head and tail. A rudimentary jaw forms a mouth, and for sound emitted from this, the head serves as the resonator or sounding-board. As the tail merely covers the posterior cell, and is not controllable as is the jaw, this can hardly be classed as a resonating influence. The Salamander presents the first structural complexity capable of affording resonance to sound.

The frog the first vocal folds.

Our third step in this vocal quest brings us to the common frog. Like his predecessor, the salamander, the frog is an amphibian, but virtually a tailless one. In the anatomy of the frog, however, we find the first creative attempt at vocal folds, so all-important in voice-production as we understand it. This trace occurs as a pair of pyramido-prismic membranes, or folds of fibrous tissue, slightly thickened, no larger than a pin's point, stationed low down on either side of the sphincteric aperture. The presence of these proves that the circular opening can be regulated at fixed points. Translated into the terms of geometry, the vacuole, or posterior cell of the Proteus, computed by the included surface of a unit sphere, has its centre at the angle's

vertex; or, in other words, the centre of the vacuole. But the presence of these two stationary points establishes a new basis of reckoning, that of the triangle. Later this will be applied to the human mechanism, namely, to the arytenoids that regulate the vocal sphincter. **Circle and triangle.**

The voice of the amphibian is of interest mainly from the standpoint of evolution. It is present in but few of the species, and in these is produced by an apparatus of the simplest kind.

Reptiles. **Turtles.**

Reptiles present a new phase, that of a rudimentary larynx. In some species of turtles we find the first appearance of an individual cricoid cartilage. By this mutual phenomenon the junction between the larynx of birds and reptiles is established. Arytenoidal cartilages control the laryngeal slit, but vocal folds in all cases are wanting. The many windings in the tracheal tubes of certain species produce the sounds that are sex-calls in the mating period.

Snakes and crocodiles.

Snakes are dumb, if we except the hissing with tongue protruded that marks a condition of excitement with them. The noise made by the rattlesnake, produced by a series of loosely jointed bony rings, cannot be classed as a voice.

In captivity the crocodile is mute, but in his native haunts he is possessed of a strong and penetrating call, at times rising to a shriek.

The larynx of the crocodile calls for comment, for it appears as a formation analogous to the human thyroid cartilage in combination with the cricoid. Its interior is furnished with a pair of septs or partitions, like shutters, corresponding to the arytenoids in that they guard the laryngeal opening. They are placed at the entrance to the organs of respiration, and by advancing toward, or retreating from one another they regulate air-communication with the lungs. These septs are present in all amphibia, even in those lacking a special larynx or voice-chamber. In crocodiles they are stretched longitudinally within their supporting ring, from front backward, moving easily. Their unattached edge is pliable, capable of thickening like a lip, representing the vocal folds.

Breath lightly expelled, as it strikes these septs, results in sounds corresponding to falsetto in man; an accession of

Young alligators. breath sets them flapping, probably hitting one another, and so changing a deep tone to a harsh, forbidding growl. But in young alligators as they leave the egg, where the orifice is but small and the cartilage undeveloped, the voice is high and piercing.

Lizards. With lizards the laryngeal structure is not unlike that of crocodiles. It appears as a ringed, cartilaginous pipe, divided into sections, and furnished with septs.

Birds. Birds, from an evolutionary standpoint, are closer to reptiles than is commonly recognized. On account of its marked peculiarity the vocal organ of birds calls for special consideration. (See Fig. 2.)

All birds have more than one larynx. One, corresponding to the throat of mammals, lies at the base of the tongue, at the top of the windpipe, but has nothing whatever to do with producing voice. It is an opening looking backward, projecting inward, without vocal folds, being nothing more than an elliptical slit, corresponding to our glottis, formed by muscles and bones, that can be compressed, dilated, and closed. Its office is to guard the windpipe from invasion of food, water and alien substances. This slit, while it does not help make voice, yet may modify its character, its closure causing the "gluck, gluck," of the hen, and explosive "k" and "g" of other birds.

The syrinx. **Thomas Huxley (1825-1895).** The true larynx, or voice-throat of birds, has been named by Huxley the syrinx, from the Greek word for shepherd's pipe, pipe of Pan, or reed. This alone produces voice, and is in some species found where the windpipe splits into the bronchials. In others it appears in duplicate, twin apparatus, so to speak, one in each bronchial duct. Ostriches and vultures are among the rare exceptions in which it is entirely absent. Generally speaking, the syrinx consists of several modified rings of which the bird-windpipe is formed, and which, when continued in the bronchial tubes, appear again as half-rings, the fissures being closed by membranous tissue. Where this joins the windpipe it projects into it some little way on both sides, forming a pair of folds, supported by a bony framework, and controlled by muscles which, by tightening or loosening their clutch, cause the size of the space

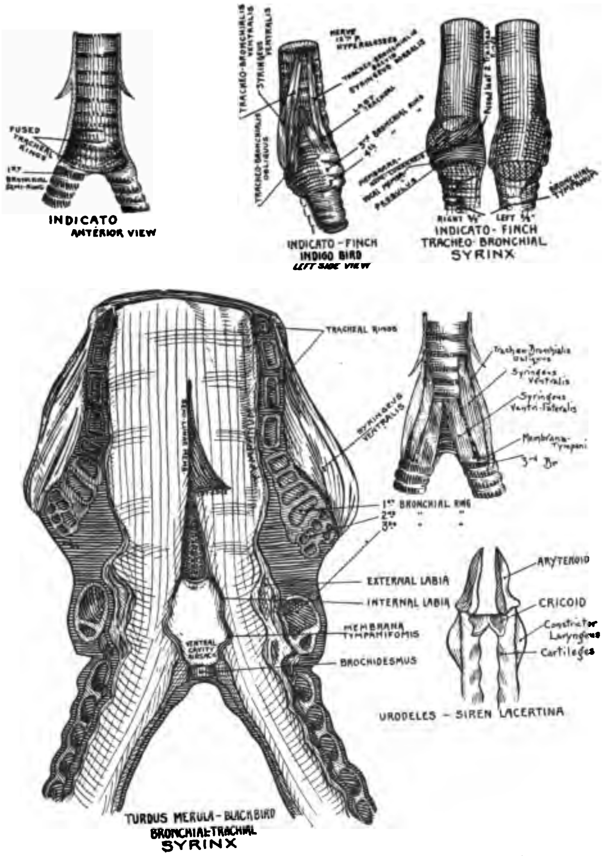

INDICATO
ANTERIOR VIEW
FUSED TRACHEAL RINGS
INDICATO - FINCH
INDIGO BIRD
LEFT SIDE VIEW
INDICATO - FINCH
TRACHEO-BRONCHIAL
SYRINX
TRACHEAL RINGS
SYRINGEUS VENTRALIS
1ST BRONCHIAL RING
EXTERNAL LABIA
INTERNAL LABIA
MEMBRANA TYMPANIFOMIS
BROCHIDESMUS
ARYTENOID
CRICOID
Cartilages
URODELES - SIREN LACERTINA
TURDUS MERULA - BLACKBIRD
BRONCHIAL-TRACHIAL
SYRINX

Fig. 2.

between the folds to vary. Air rushing from the lungs through the bronchi and into the trachea by way of this variable opening furnishes the motive power to voice, and the disturbances, interruptions, and modifications, to which this sound-column is subjected on its outward journey, form the bird quality.

Sparrow. Trumpeter swan.

The principal modification arises from the reverberation caused by the impingement of the air on the elastic walls of the ducts. Special modifications in structure cause special qualities; certain ducks, for instance, are furnished with an apparatus that produces drumming sounds, consisting of a bony vesicle, or bladder-like formation, covered with a tympanic membrane like a drum-head. The number of rings composing the tracheal duct, as well as its relative strength, will qualify reverberation in bird-vocalism. Fifty annular formations, Beebe tells us, go to make up the windpipe of the young English sparrow, while the trumpeter swan boasts a windpipe four feet in length, half of it coiled up within the breast.

William Beebe, curator, N. Y. Zoölogical Park.

To reproduce bird-tones by a mechanical means is in general not difficult. The hollow stem of a plant, cut obliquely at one end, and the opening thus formed covered with a thin, skin-like texture, will give an elementary syringeal apparatus in inverted position, when blown through at the free end. By adding a pipe to the covered end we now represent the tracheal reverberation. Narrowing the vocal slit, while increasing the air-pressure, lifts the tone. Shortening the additional pipe also effects this on computable bases. The tension and quality of the modifying tissue also must be taken into account. A small piece of birch-bark, rolled into a tube, and covered with a tender leaflet, makes a simple syrinx with which any one can reproduce bird-voice.

Though the syrinx occurs in duplicate, the bird can produce no more than one tone at a time. The adjustment of vocal slits is probably uniform, and the two air-columns meeting in the trachea become voice by the momentum established at the pessulus.

Baron Cuvier (1769-1832).

To the great naturalist, Cuvier, we owe the most searching and minute studies of the mechanism of bird-voice.

Johannes Müller (1801-1858).

Savart and Johannes Müller also are among those who have contributed valuable data.

With the conclusions drawn by some of these authorities, however, I do not find myself always in accord. The author's theory, briefly stated, is that the bird organ of voice is at no time to be compared to an open or flute-pipe, even when it gives forth the shrillest twitterings and whistling sounds, but must, at all times, be considered a membranous reed-pipe.

Reed or tympanic membrane.

In this connection let us note that the term reed now is applied to the structures that interrupt the passage of the outrushing breath, though these structures are made of metal. In the bird these reeds also are called tongues, and again tympanic membranes, though the drum character usually associated with the latter word does not apply here. Searching for another meaning, we find that tympanum once was applied to a stringed instrument resembling the ancient Irish fiddle, the crowth, played upon with a bow, and from this the general idea of vibration and reverberation were obtained. These tongues, as Cuvier has pointed out, are susceptible of innumerable changes in tension and form, and these changes account for the infinite variety of sounds, cries and songs that are the speech of bird-life.

Voice automatic.

Therefore, bird-voice rests upon the same principle as that of mammals. The vocal apparatus, in both, is a membranous reed-pipe, though in the former, owing to the smallness of the vocal membranes, the change in pitch depends upon the force of the air-pressure, and the solid elastic consistency of the additional tube. Such, as is well known, is not the case in man.

Form sphincter.

We leave voice, from the evolutionary standpoint, where it is conditioned not only by pitch and power, but with the added factor of some resonance, as a result of a membranous reed-pipe. The complexities of the human organ are such that we must review this structurally before analyzing the sounds it can produce. One thing, however, must be noted, and that is, that initial voice is from first to last automatic, made by an aperture, and that that aperture is regulated by a sphincter, an automatically

opening and closing muscle, as comparative anatomy shows conclusively.

And so from the two first makers of sound in organic life—namely, the gaseous detonation from the contractile vacuole of a protoplasmic cell, which, in its turn prototypes the amphibian sphincter with its equally automatic gaseous detonation, both sounds, however, merely presenting a monotone pitch conditioned with some measure of power but lacking in quality—we ascend in the scale to the birds with their varied and wondrous songs, and thence to the "Lyre of Seven Strings, the Lyre of God," that, according to the old Orphic fragment, vibrates within the human frame.

CHAPTER III

The Vocal Tract

Voice subjective and objective.

Voice is sound; voice is what one hears. That is the subjective aspect of the phenomenon. Considered as an effect on the brain, it is a sensation caused by some disturbance of the auditory nerve. Objectively, we speak of voice or sound as the external source of such disturbance. To a deaf person, one born with non-recording ear-drums, sound subjective is a meaningless term. When the organ cannot function, the mind cannot perceive the external world in sound-manifestations. The door is closed and locked, barring the cosmic message by word of mouth to the soul—tone is dead. Voice objective, however, may be as manifest and as clearly demonstrated, according to its origin, to the wholly deaf as to those of acutest aural sensibilities. Voice objective is physical, a thing occupying space, that can be reckoned in terms of energy, computed mathematically, photographed, analyzed into components, and analogued with other natural phenomena, as for instance light. Voice subjective also is physical, but is computed by its effect upon the hearer. That it is phonetic is due to the fact that it appeals to the ear. Voice kinetic is a form of motion, and can be realized by eye and touch, as proved in the education of the deaf.

Voice, or sound, originates with some body in a state of rapid vibration. These vibrations transmit their energy in the form of wave-motions to the surrounding medium, which in our present study is the air about us.

Vibrations.

Vibrations are the small motions of the body, or its motions within a restricted area, recurring at regular intervals, back and forth, as with a pendulum. These regular recurrences constitute the body's period of motion.

A period for a pendulum means the time it takes to travel from the central point of its arc to each terminal and back again. In the illustration we would have a period for the pendulum represented by its swing from "M" to "N," thence to "P," and back to "M." A period,

Periods.

accordingly, consists of a double vibration, one in each direction. Half the swing that is from central point of arc to either terminal describes the vibration's amplitude. The number of periods or double vibrations occurring in each second of time represents its frequency. A period of one-tenth of a second means a frequency of ten double-vibrations to the second.

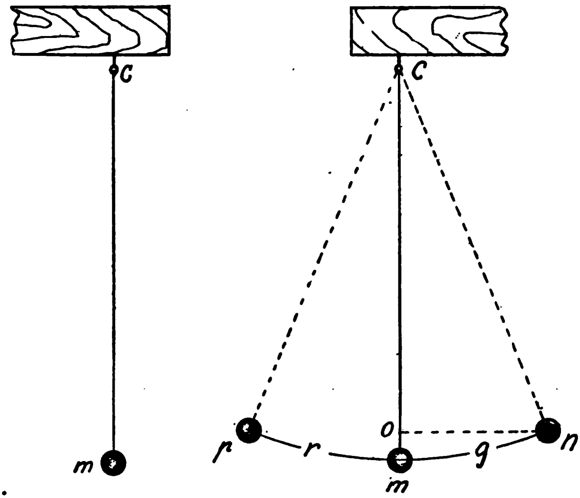


Fig. 3. Period of Pendulum.

Amplitude.

Vibrations transverse or longitudinal.

Vibrations are described as transverse when the motion, or source of propagation of the motion, is at right angles to the greatest length of the body; and as longitudinal, when in the same direction as the greatest length of the body.

Periodic vibrations affect the particles of the medium about their source periodically, producing waves. A wave, therefore, may be defined as periodic vibration in a medium, caused by a periodically vibrating source. Any body, such as a string, a membrane, or a mass of metal, set vibrating, causes particles of air about it alternately to condense and rarefy. Each particle thus energized vibrates a short distance longitudinally, that is, in the direction of the source of propagation, and in so doing transmits its energy to other particles. Obviously, the air as a mass does not move on, because of its elasticity; regularity of this disturbance constitutes the wave, just as the periodicity of movement at the source constitutes the vibration. Putting the hand under the tablecloth and drawing it along gives a crude idea of wave-motion. The tablecloth as a whole remains stationary, but a local con-

figuration is passed along its surface. When considering vibrations we speak of the period, the time between similar consecutive configurations; the frequency, or number of periods in a unit of time; the amplitude, which may be said to equal one-half of the maximum displacement; and the distance between adjacent configurations, constituting the length of one wave.

Motion of wave-particles.

It must not be forgotten that the particles of the transmitting medium have a motion independent of that of the sound-wave itself. The particles, condensed, move forward in the direction of the force affecting them; rarefied, they move backward. Meanwhile, both condensation and rarefaction are traveling onward with a speed

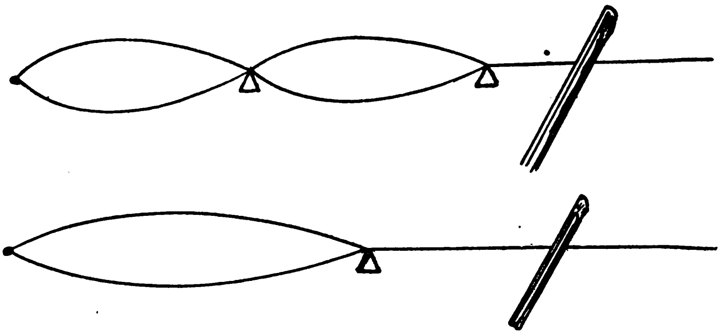


Fig. 4. Loops and Nodes.

conditioned by the temperature of the air and the medium itself.

Harmonic motion.

Phase.

Simple harmonic motion arises from a single series of vibrations with regular periodicity. "Phase" describes the vibrating body's return at any moment to the point of the motion's origin, as, for instance, the pendulum to the centre of its arc. Vibrating bodies, otherwise identical, may differ in phase through not having been set in motion simultaneously. A series of vibrations may produce a complex wave, harmonious in results because composed of factors in themselves harmonious. They are illustrated geometrically and computed in numbers.

Reflection.

Reflection ensues when a sound-wave encounters an obstacle in its path. Some of its energy is transmitted

to the new mechanism and some thrown back. When, through such interference, a system of return waves is created, no motion exists at the point where the two series intersect. Such points are called nodes; and the points of widest divergence, loops. **Nodes.**

Musical sounds and noise. The difference between a musical sound and a noise, subjectively considered, is that the former affects the hearer with a sense of pleasure. Kinetically stated, musical sound has its origin in vibrations that are regular, continuous and uniform, while mere noise originates in an irregularly vibrating source. The less continuous the vibrations causing unmusical sounds, the more abrupt their changes and the further from a sense of pleasure is their effect upon the ear. Our concern is with the pleasurable only.

Musical tones. A musical sound received by a normally sensitive ear presents itself either as a simple tone, or one of a complex nature composed of several tones. The sound of a tuning-fork exemplifies the former, while that of a violin, the human voice, etc., exemplifies the latter. Even the clash of cymbals cannot fail to strike one as capable of being resolved into component strands. The pure tone is produced by a simple harmonious wave; all others have a complex origin. The trained ear, hearing a tone, assigns to it a place higher or lower, according to its pitch (vibration number) in an arbitrary scale. In the case of a complex musical sound the pitch is always determined by the predominating tone, which is invariably the lowest or fundamental tone; all the other components are called partials, or overtones. Pitch is determined by relative frequency in the vibrating source; the greater the frequency the higher the pitch. In a series of tones the pitch of each is the relative frequency of its fundamental; in a single complex tone its pitch is the lowest frequency present. When the overtones present frequencies that are exact multiples of the fundamental they are called harmonics.

Loudness. Loudness in a tone is a characteristic which affects its intensity and to a certain extent involves pitch. The quality of a tone is a property that enables us to recognize the source of the sound, whether stringed or wind-instrument, horn or harp, inanimate or human, woman or man.

Soprano pitch, from the standpoint of the hearer, is a position in the scale; loudness, the relative energy with which the sound affects the ear; while quality or individuality comprises everything not belonging to the other members of the trinity. Physically stated, in terms of the sound-waves, pitch depends upon their length, since wave-length is inversely as frequency; loudness or power upon their amplitude; and quality may be analyzed into the number and relative intensities of the partial tones.

Intensity. A distinction may be drawn between intensity and loudness. Intensity results from the amplitude of both fundamental tones and overtones; loudness, when the amplitude of a single vibration is strongly predominant.

Beats. Beats occur when two sets of vibrations of almost the same frequency affect the ear simultaneously, causing a pulsation without harmonious relation in its components.

H. von Helmholtz (1821-1894). Helmholtz explains consonance and discord as an arbitrary preference of the human ear for effects resulting from components in a definite mathematical relation from which these pulses are absent.

Segmentation. Segmentation is a phenomenon that occurs when a vibrating body for some cause is set vibrating in sections, each section yielding tone in a definite ratio to the fundamental. Nodes and loops, as we have seen, result when two trains of waves, traveling in opposite directions, traverse a vibrating body.

Resonance. Resonance is a sound-phenomenon to be studied in connection with vibration. Any vibratory body that is disturbed, set in motion, plucked, swung, or blown upon, executes what are called free vibrations; that is, vibrations that depend on its intrinsic period, since periodicity is an organic quality. These vibrations will gradually decrease in amplitude as the energy they represent is transferred to the surrounding medium, till finally they cease, a process technically known as damping, yet the last slow swing takes no less time than the first completed movement of activation. Resonance requires the presence of a second vibratory body, such as a string, a metal bar, or an air-cavity, with a period in some definite correspondence with that of the first. The vibrations of the first body are

forced upon the second through their relation in periodicity. Reflection, as we have seen, is a bending back, with loss of power; resonance is a sending back to rejoin, consequently a reinforcement. Amplitude—power—may be increased by this property which one body possesses in exciting another of the same or similar vibratory period, to a degree that at first seems to pass belief, so gigantic are its possibilities. The destruction of a suspension bridge, through the swinging step of a regiment coinciding with the period of the metal, is an historical fact. In the "Sunken Bell" a natural law may have played its part in the poet's dream when Heinrich cries, "Hark how the buried tones swell louder, louder, till they sound as thunder, flooding the world!" And to resonance we owe all that is poignant and personal in the human voice.

Summing up, it will be seen that voice—what we hear—is produced not only by air-waves excited by a vibrating source, but is also the result of a corpuscular theory; that a musical sound results from regularity in the vibrating origin; that a musical tone presents three characteristics: Power, quality, pitch; that power is referred to wave-amplitude and corpuscular expansion; that quality is due to complexity caused by several tones in the relation of the fundamental and harmonics, all being present in one tone, the complexity exhibiting the combined pitches and relative strength of these components in the phenomenon of resonance; that pitch, the relative place in an arbitrary scale, is physical, and determined by frequency of vibration.

Evolution proceeds from simple to complex.

From this brief review of physics in relation to sound it will be obvious that any simple sound must be conditioned by some measure of power, and must be referable to some pitch, but that the second factor of musical tone, quality, depending on resonance, can be produced only by structural complexities capable of furnishing reverberating systems for tone-components. Now, as nature progresses in the scale of evolution from simple to complex, obviously the development of the resonating apparatus will be the measure of vocal advance, from the protozoic makers of monotone pitch, conditioned with some power, but no

quality, till we reach the twenty-four resonators in the human frame.

With this in mind, let us consider the human organism structurally, in the special parts assigned to the actual work of sound-making, in the special parts assigned to reverberating tone-components, and as a general structure designed for automatic voice-production.

Pharynx. The first structure to be considered is the pharynx. The word comes from the Greek word "to plow," and means a furrow, a channel. The pharynx is a pouch of membrane and muscle forming a joint opening for the windpipe and gullet; in other words, the trachea and esophagus. The pharynx extends from the base of the skull down to a point between the fourth and fifth cervical vertebræ, and is in length about five inches, with a maximum diameter of one and three-fifths inches. It continues from below with the esophagus above; it connects with the middle ear by the Eustachian canal, and in front extends into oral and nasal cavities. Of these the pharyngo-nasal is concerned in respiration and in modification of voice, while the pharyngo-oral in connection with the pharyngo-laryngeal has to do with respiration and deglutition.

Bartolomeo Eustachio (died 1574).

The pharynx is the upper opening for trachea and esophagus. The upper portion of the trachea, enlarged and modified, is the larynx.

Trachea. The windpipe received the name trachea from two Greek words signifying rugged air-duct. A tube of muscle and membrane, stiffened and held open by a series of cartilaginous rings, it splits at the base into the bronchii, and spreads at the top into the larynx.

Larynx. Larynx is Greek for throat. The larynx is a complicated structure, designed for two purposes; to serve as transmitter of air, and as the organ of phonation, or the sound-producer. It is a box, a chamber, with a framework of cartilaginous formations, bound by ligaments, lined with mucous membrane, supplied with blood-vessels and lymphatics, and controlled by muscles with their special innervations. It is bounded above by the hyoid bone or tongue-bone; laterally by the great vessels of

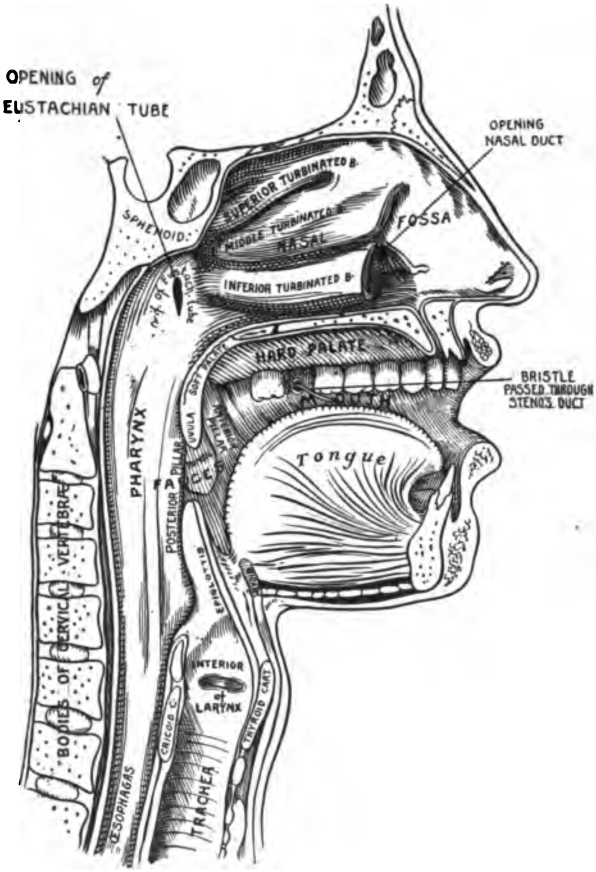


Fig. 5. Pharynx; Eustachian Tube.

head and neck; and in front by the oral cavity. Its posterior surface is formed by the anterior pharyngeal wall. Below, it continues with the windpipe.

Cartilages of larynx.

The cartilages of the larynx are to be considered as three single and three pairs. The former, or single cartilages, are the cricoid, thyroid, and epiglottis; the latter, or the cartilages occurring in pairs, are the arytenoids, the cartilages of Wrisberg, and the cartilages of Santorini. Thyroid and cricoid cartilages are annular, being modifications of the tracheal tube, the lower of these being the cricoid.

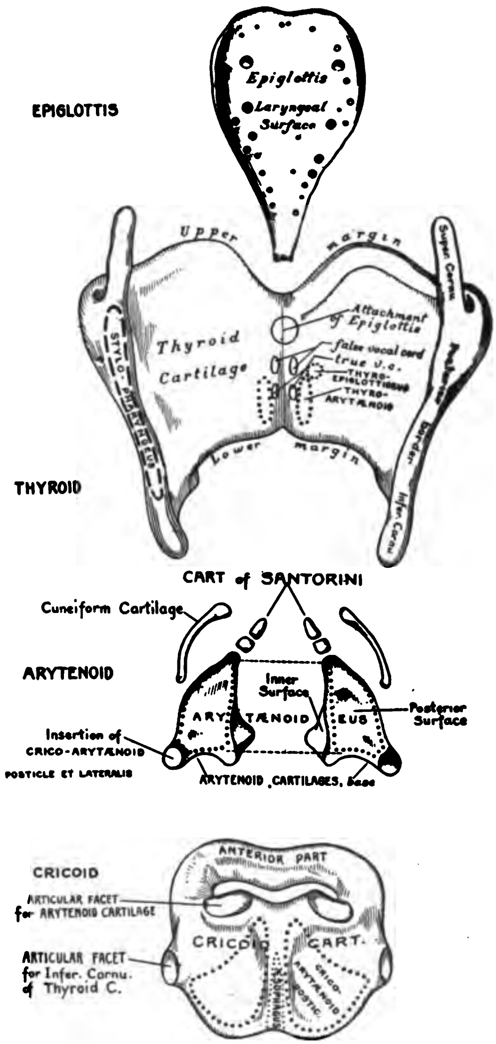


Fig. 6. The Cartilages of the Larynx.

Cricoid.

The name cricoid is derived from the Greek *krikos*, which in Latin is *circus;* literally it means ring-like, a description emphasized by the way this structure expands at the back into an oval causing it to resemble a signet-ring. At the back it serves as base for the thyroid; in front there is a slight space between the

thyroid and cricoid, a depression that may be felt with the finger below the Adam's apple.

The name thyroid comes from the Greek *thureos*, a shield, which in turn is derived from *thura*, a door, folding doors or valves, as of a shell. The thyroid, which is the largest portion of the laryngeal chamber, consists of the two squarish shield-like plates, joined in front along their edges, and projecting at the upper part of this junction in the Adam's apple. The included angle of about ninety degrees is inclined somewhat obliquely, looking forward and down, toward the cricoid. Spreading apart as they retreat, these shields or wings (*alae*) rest their bases at the back, without meeting, upon the cricoid oval. Their superior edges, in retreat, rise in an upward prolongation, like the horns of an animal, to form points of attachment by means of ligaments for the hyoid bone.

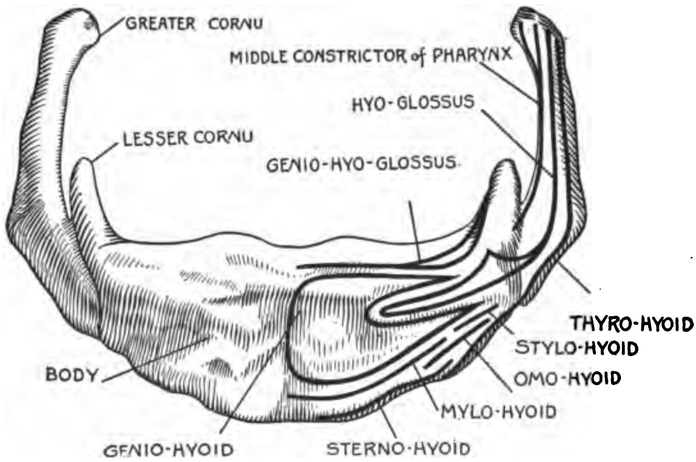


Fig. 7. Hyoid Bone, Anterior Surface (enlarged).

Hyoid bone. Hyoid comes from the Greek *huo-eides*, U-shaped. This is the tongue-bone. Lying well above the Adam's apple, about level with the lower jaw, its horseshoe curve to the fore, and its prongs running horizontally, the hyoid bone forms the basis of the tongue structure and the superior attachment of the larynx, the muscles moving it being common to both these constructions.

But to return to the laryngeal cartilages; epiglottis comes from the Greek *epi*, upon, and *glottis*, the mouth, in this connection meaning the mouth of the trachea, the glottis. The epiglottis is a flexible, fibro-cartilaginous formation, somewhat leaflike in shape, with dimensions that vary with individuals, but always with the stalk below, at its junction with the base of the tongue, and the expansion above where it is seen as a cushion with a lip. At rest it stands erect, allowing air to pass freely over its well-mucoused surface, but the slightest excitement, as the act of swallowing, causes it to incline automatically backward so as to serve at once as lid to windpipe and bridge to esophagus. **Epiglottis.**

The principal pair of laryngeal cartilages are the arytenoidal. *Arutaina* is Greek for cup, pitcher, any vessel for taking up liquid. The arytenoids are two small, slightly cupped, pyramidal cartilages with triangular bases, set within the thyroid area, upon the cricoid oval, on which they are freely movable under muscular control. From the base of each projects a small spur, the *processus vocalis*, or vocal process. These form the posterior points of attachment for the vocal folds. **Vocal process and muscular process.**

Another small projection from the arytenoids is the muscular process, on which are borne the cartilages of Santorini.

The remaining cartilaginous pairs occur within the aryteno-epiglottidean folds. As these folds approach the arytenoids they show a pair of small, wedge-shaped prominences, somewhat like pyramids with apex directed outward, the cuneiform cartilages or cartilages of Wrisberg, and beyond these, borne on the arytenoids, are found the small conical formations called the horns of the larynx (*cornicula laryngis*) or cartilages of Santorini. **H. A. Wrisberg (1739-1808).** **Santorini (1681-1737).**

There are three pairs of laryngeal folds, all with their posterior base of attachment at the arytenoids; namely, the aryteno-epiglottidean, ventricular, and vocal. The aryteno-epiglottidean form the lateral boundaries of the upper laryngeal opening. They extend, one on each side, from the epiglottis downward and backward to the arytenoids. Their dimensions vary with individuals, and also

with different states of the larynx, being broad when relaxed, as in inspiration, and narrowing with tension when the vocal folds are approximated.

The ventricular bands, as Dr. Mackenzie aptly named the "false vocal cords," lie below the aryteno-epiglottidean folds. They are thick, rather prominent folds of mucous membrane.

The vocal folds, erroneously described as cords, are two strong bands of elastic tissue, inserted anteriorly, one on each side of the thyroid angle and passing in a posterior direction to the bases of the arytenoids. At the front their fibres are collected into one formation. Posteriorly these separate into three divisions, with several subdivisions, spreading the area of insertion from its principal point of attachment at the vocal process upward, some of the fibres also reaching the cricoid cartilage at its superior margin. In length they are slightly over the half-inch for men and somewhat under it for women. A side view of these folds and a vertical section parallel with the anterior portion of the spine show them to be pyramidal in form; two of the lateral spaces of this pyramid being free, one directed toward the ventricular band, the other downward and inward, and the third being the attached face. At inspiration they almost meet in front, while posteriorly they are separated by a span from a quarter to half an inch. The space between them is the *rima* (Latin for fissure, chink) or glottis.

The glottis is bounded by these vocal lips for two-thirds of its extension, the remaining and posterior third lying between the arytenoids. *Rima vocalis* describes the former, *rima respiratoria* the latter, while the whole forms the *rima glottidis*. (See Fig. 8.)

On inspiration a diagram would show the glottis as a lozenge-shaped aperture, the angle at the back being pushed outwards. Another diagram giving the vocal folds approximated, or brought close one to the other during phonation, shows this glottis angle turned inward, the space enclosed forming a truncated V.

Laryngeal cavities.

Between the sets of laryngeal folds are small cavities or pockets. Those between aryteno-epiglottidean folds

above and ventricles below appear as small depressions during the approximation of the vocal folds. They are called by Mackenzie "*fossa innominata*," the pockets without a name, and by Vocal Art-Science universal, accessory, adjustable, auxiliary resonators.

Sir Morell Mackenzie (1837-1892).

Between the false vocal cords above and the vocal lips below are the ventricles, from the Latin *venter*, the belly, stomach, or any kind of cavity.

Fossa innominata. Ventricles.

So far as phonation is concerned the larynx may be said to exist for the sake of the glottic opening. Its carti-

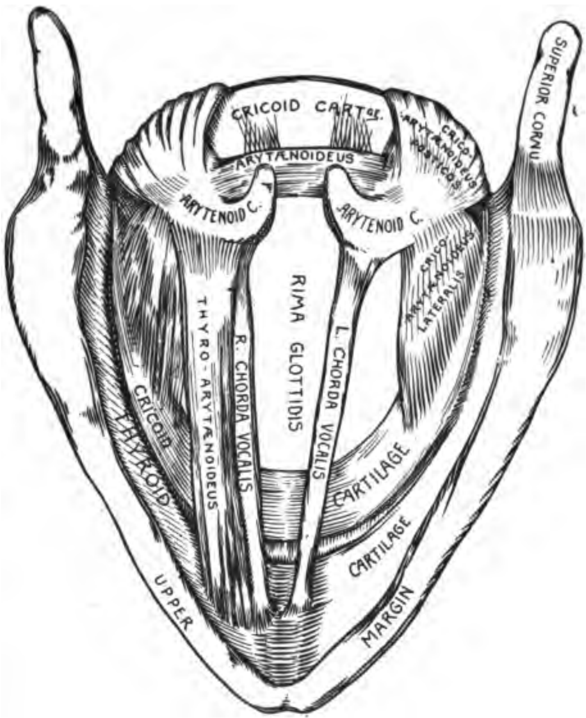


Fig. 8. Interior of the Larynx. Seen from above (enlarged).

lages form points of attachment, and, in the case of the arytenoids, pivots for the vocal folds. These, under muscle control, vary the size and shape of the opening according to need; and as this mouth of the windpipe is

shaped in sound-producing, so is the individual character of the sound produced.

Position of larynx.

Freely movable, the larynx ascends and descends during the processes of respiration, phonation, and deglutition. When it is at rest, with the head held erect, its position brings the middle of the thyroid cartilage opposite the fifth cervical vertebra, and the whole organ from the tip of the epiglottis to the lower border of the cricoid corresponds in position to the third, fourth, fifth and sixth cervical vertebræ.

Laryngoscopic observation of color scheme.

A laryngoscopic examination of the larynx during quiet in-breathing shows the epiglottis with a dull pink upper surface, the lip inclining to yellow, the cushion red; the aryteno-epiglottidean fold the same color as the gums, with the cartilages of Wrisberg rising from them in pinkish prominence; next, the cartilages of Santorini; then the ventricles below the ventricular bands, which are of a deeper red than the aryteno-epiglottidean folds; the pearly white bands of the vocal lips, and below these the broad yellow of the cricoid; and at greater depth the tracheal

With psycho-physical bearing.

tube with its annular cartilages, the mucous membrane between them showing a pale pink—a color scheme which has a psycho-physiological bearing, as we shall see later. Meanwhile, the larynx as an organ of phonation must be considered with these associated parts.

Supra-laryngeal section of vocal tract.

Oral and nasal cavities comprise the supra-laryngeal section of the vocal tract. The laryngeal section forms the actual organ of phonation or sound-making, yet sound would be neither speech nor song without the enhancement and modifications afforded by supra-laryngeal aid. Air passed on from the larynx is detonated into the upper chambers of the vocal tract, by way of the pharyngeal hood, into the nose and mouth. Before it can enter the latter it must pass between two sets of pillars, one after another, and under a hanging curtain. The narrowed passage between the two pillars of each pair is the isthmus; the space included by the two sets, the fauces. The fauces may be regarded equally as vestibule to the pharynx, and back chamber to the buccal cavity or cheek enclosure. Regarded from the latter point of view (that is, of one

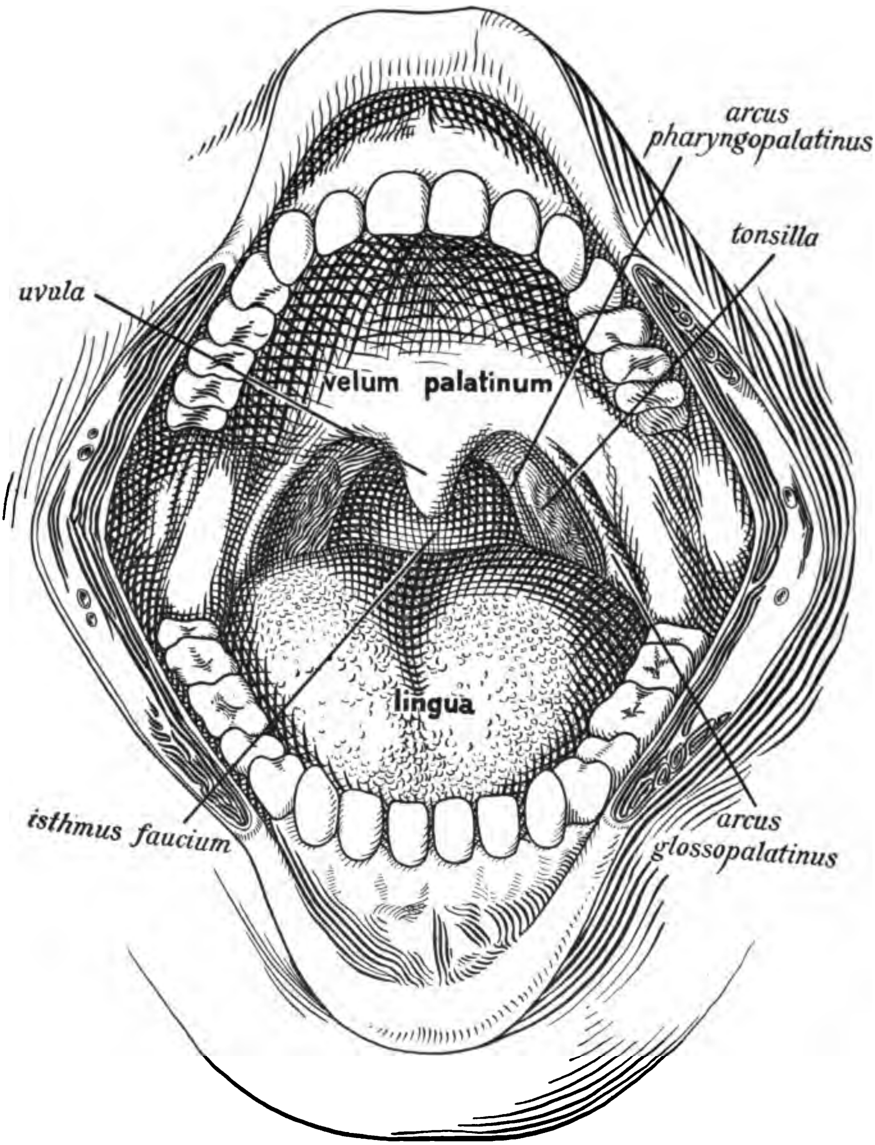


Fig. 9. Oral Cavity.

person looking down the throat of another), the pillar-sets are named respectively anterior and posterior. They are seen to be slight prominences formed by projecting longitudinal folds of mucous membrane, the anterior in the palato-glossal muscles, the posterior in the palato-pharyngeal muscles. Their office is to afford support to the palatal arch. Air passing by way of the isthmus through the fauces impinges upon a pair of ovoid bodies, stationed sentinel-like, one on each side in the faucal recesses—the tonsils. *Tonsa* is Latin for a stake, *tonsilla* for an oar, a stick stuck in the ground as mooring for a boat. The tonsils, however, contribute less of an anchorage than an easement to vocal mechanism. Dr. Faulkner describes the anatomical and functional advantages of the firmness they impart to the pharyngeal wall, by calling attention to the fact that the muscles of the pharyngeal wall insert fibrous fingers into these compressible formations and, playing upon them, knead their spongy substances as if they were cushions, thus markedly affecting the shape of the cavities in which they lie, and so affecting voice.

Tonsils.

Dr. Richard B. Faulkner, Columbia University.

Stretched from one anterior pillar to the other hangs the curtain of membrane and muscle, the *velum palati*, the palatal veil, also called the soft palate. In the middle of the free border of this its substance thickens into a small, grape-like formation, the *uvula*, the diminutive for the Latin *uva*, a grape. The soft palate is but an extension of the hard palate, the bony structure which serves at once as floor to the nasal, and arched roof to the buccal, cavity.

Uvula.

Hard palate.

Lying on the floor of the mouth, firmly anchored at its root to the hyoid bone, but freely movable as to the rest of its fleshy, flexible mass, is the tongue, over and about which air must pass before finding egress at the *rima oris*, the mouth-chink. Tongue, teeth, lips and cheeks all have their office in phonation, as modifiers.

Oral cavity.

The pharyngo-nasal domain is a construction of many chambers. The pharyngeal arch, or dome, communicates with the nose by way of the *choanæ*, or funnels. The nose itself is divided by the nasal septum, an extension of the *vomer*, from the Latin for plowshare, consisting of a

Choanæ and nasal cavity.

pair of thin plates, joined as they project from the basi-cranial formation. The whole nasal cavity is subdivided by the turbinates, three pairs of small, slightly whorled bones, respectively called superior, middle and inferior, which are important to resonance, though without being muscularly acted on. (See Fig. 10.)

Structurally, the vocal tract consists of laryngeal and supra-laryngeal apparatus, extending from the glottis, the momentic source of sound, to nose-tip and lips, the final resonantic vocalic influence. Functionally it must be studied in connection with the muscles, with their innervations, which control its valves and cavities, so that sound and voice may fulfill the initial condition of automatism, modified by power, quality and pitch.

CHAPTER IV

The Vocal Autonomies, or Voice Units

Voice, the divine, is automatic. Voice, what we hear, is a form of energy produced by a series of coördinated muscle-actions.

The vocal apparatus may be influenced by seventy-four muscles and sixteen nerves. Granting to these individual and conjoint action, and assuming that they do operate also in pairs, we have a possibility of alterations in the vocal mechanism to the number of some 74,682,000, and calculating the mental impulses, we have 14,000,000,000,000. Those who insist on conscious muscular control in the production of tone in its last analysis, hardly can have contemplated how many such conscious muscular controls are requisitioned in a single intoned syllable.

Fortunately, however, for the purpose of study, these muscle-actions can be massed in groups, each of which contributes a clearly defined act to the act of phonation.

Muscles, voluntary and involuntary.

Muscles, generally speaking, are organs of motion. A muscle consists of a bundle of fibres attached by their extremities to parts of the body that require to be moved. These fibres have the property of contractility under stimulation, the contraction being determined by a nerve proceeding to the fibres from some nerve-centre, either cerebral or sub-cerebral. If the will calls upon a certain muscle to perform a definite action, or again, inhibits that muscle from proceeding with the act, the muscle under control is called voluntary; while a muscle that automatically serves the ends of animal life independent of the will, is called *involuntary*. The former, or voluntary muscles, appear as streaked, or striated; the latter, or involuntary, as unstriated, or unstreaked.

Line of demarcation not always to be drawn precisely.

There are times when, functionally speaking, the demarcation between the two kinds cannot be drawn with absolute precision. There are times when voluntary

and involuntary muscles working in concert, impart to the resultant act something of the characteristics of both. And, again, voluntary acts that the will could inhibit, should it choose to exercise its power, or excite, may be performed automatically, as happens with breathing during sleep.

Muscles and muscle-groups therefore must be considered in the light of the power which governs their motor-activity, the structure by which this power manifests itself in action, and the product of the special act in relation to the desired result.

Voice, the product, is the result desired. The will accordingly stimulates its nerve-transmitters on the lines of voice; these in turn rouse to action the muscular system of levers and locks, valves and gauges, by which air is transformed into sound; and the act of breathing, organic, automatic, or involuntary, resolves itself into the deliberate, voluntary, and conscious art of speech and song.

So complex is this system that it can be approached only in sections, or determined by the separate acts each factor contributes to the desired result.

In the vocal series, each of these muscle-action groups is to be treated as an autonomy. *Auto* is Greek for self, and *nomos* for law. An autonomy is a self-governing institution or community. In phonation, then, autonomies, or (as they may be called) centres of force, are divisions of the vocal tract, comprising factors in the vocal mechanism, each consisting of a distinct physical construction that contributes a definite act to the series necessary to produce voice. These centres of force are also capable of acting under the direction of both the intellect and will, and through education or habits of culture may respond automatically, according to the laws of expression. As parts of the body, they must of necessity be considered anatomically and physiologically. As physical constructions, they are subject to the laws of mechanics; yet for the reason that the effect of their combined forces results in a personal expression, it carries them into the kingdom of psychology.

Here let it be noted that physiologically these autonomies have duties other than purely that of voice-produc-

tion. Breathing, bronchial protection and swallowing, coughing and sneezing, all lie within their province. But as they inhibit one function while performing another, these may be dissociated in order to consider them simply as factors in voice-production or song.

Polarity of units. Every cell in a living organism is polarized. That is to say, it lives by maintaining a balance of power between two working antagonisms, two different qualities, or two manifestations of force acting one in opposition to the other. Its poles are the points at which these two opposing energies are concentrated. They are the regional forces of the two bases, the central points of action and resistance. In this respect the vocal autonomies are cell-like; they have polarity. Each may be considered a huge cell, with a mechanical centre of resistance which is related to the unit's physiological function. This also may be called its point of poise. Poise in each member of the group secures poise in the whole machine.

Point of poise.

Names of autonomies. Named from the region of the body in which they lie, these units, five in number, are the Oral, Nasal, Laryngeal, Thoracic, and Abdominal.

Abdominal unit. The Abdominal or Dynamic Unit is the foundation of the vocal temple. It lies between the diaphragm and the sphincter ani, the large, fan-like muscle drawn about the posterior orifice, and includes the end of the spine. Diaphragm and sphincter ani form its poles of power, with their contrapuntal points at the umbilicus, or navel, and the third lumbar vertebra. The point of poise of this autonomy, its mechanical centre of resistance, is at the navel. Its muscles, with their nerve-supplies, must be considered in connection with those of the unit above. Because of the character of the support it affords the voice, it may be called the Semi-Solid, the Supportive. Because of the function it contributes to the series, it may be called the Dynamic.

Supportive or dynamic unit.

Thoracic or pneumatic. The Thoracic Unit lies between the vocal folds and the diaphragm, with the upper section of the rib-chamber enclosing lungs and heart. Diaphragm and vocal folds furnish its poles of power, with their contrapuntals at the fifth dorsal vertebra and the manubrium (from the Latin

manubrium, a handle), which is the upper segment of the sternum or breastbone. Its point of poise is at the sternum. This gaseous, bellows-like construction is the region of air-control, whence its name of Pneumatic Unit arises.

Laryngeal or momentic unit.

The Laryngeal Unit lies between the vocal folds and the structure formed by the base of the tongue, the palate, epiglottis and pharyngeal walls. In this the physiological control is exerted by poles of power with contrapuntals, the influence of which is felt between the crico-thyroid membrane and the fifth cervical vertebra. Its point of poise is at the crico-thyroid notch. This autonomy is the central region of phonation, where air-strokes are converted into sound, or voice. Air detonated from the spaces below into this cavity, between the ever-resisting vocal folds, develops a moment of force (from the Latin *momentum*, for *movimentum*), giving this Unit the name of Momentic.

The oral or articulate unit.

The Oral or Vocalic Unit is the chamber formed by the mouth-cavity. It extends from the lips to the pharyngeal walls. Its poles of power with their contrapuntals exert their influence between the lips and the structure formed by tongue, soft palate, and epiglottis. These fan-like sphincter muscles with their valvular action determine the unit's physiological control. Its mechanical centre of resistance is at the arch of the hard palate, on a level with the eye-teeth. Since this is the region where sound detonated from below is converted fully into the tone-shapes that form speech-elements, it is called the Vocalic or Articulate Unit.

Nasal or resonantic unit.

The Nasal or Resonantic Unit includes the nose-cavity, and that formed by the superior portion of the pharyngeal pouch or dome. Its poles of power with their contrapuntals are found at nostril openings and palate closure. Its point of poise is at the bridge of the nose. This is the special region of resonance, every cavity furnishing a reverberating system for some portion of sound.

The Oral Unit presents, with the other supra-laryngeal units of the vocatorium, the greatest complexities of structure favorable to sound-modification. From an evolutionary standpoint, accordingly, it fulfills the last con-

dition in voice-production by adding to pitch and power the completing member of the trinity: Quality.

In seeking the special reverberating system furnished by these supra-laryngeal units, we find the highest structure formed by a hollow, bony basin between the eyes, called the frontal sinus, and surmise what later we shall prove by mechanical demonstration, that this forms the resonator for the highest overtone, or is the highest place an echo can reach from the fundamental. This labyrinthian structure called the frontal sinus we already know as a place of many chambers, and as these chambers furnish reverberating systems for tone-components, the Unit also is called the Resonantic. Going down a step, we find that the next resonators, the turbinates, take charge of the lower overtones, reflecting their sound as it strikes them, while at the same time directing them into the frontal, antral, mastoidal and sphenoidal sinuses.

The seven overtone forming spaces are controlled in the following sequence by

(1) Epiglottis
(2) Palate
(3) Mouth and tongue
(4) Palate, tongue and dome
(5) Middle turbinated bones
(6) Inferior turbinated bones
(7) Superior turbinated bones and frontal sinus.

Having thus added to tone-components the third physical attribute, the completing member of the trinity formed by pitch, power and quality, we may now recall the physiological attribute that the dual nature of humanity demands. About these supra-laryngeal units centre the five special psycho-physical senses: Touch, taste, smell, hearing, and sight. Voice, automatically produced, rises to the floor of the brain which controls the function of these senses, being thus borne to the very throne of the kingdom of psychology.

Ever since the days of Porpora, the teacher has insisted, "Sing through the nose!" To-day the wisdom of the old Italian masters is still with us, but with our wider scientific knowledge we are able to add certain

Niccolo Antonio Porpora (1686-1766).

pitch-values and metaphysical developments to the truths they taught.

Fig. 10 shows the Vocatorium, the united organs of voice where pressure of compressed air at the lungs creates momentic strokes or spiral sound-thrusts upon the vocal valves. Thus larynx and spaces below the hyoid form the Momentic region.

Above the Momentic, surrounded by lower pharynx,

Fig. 10. Vocatorium.

tongue and under side of soft palate, is the Sonoric region, where these spiral tone-thrusts are modified by resonators into tone components.

Above the Sonoric is the Resonantic, closable from below by soft palate and mid-pharynx muscles.

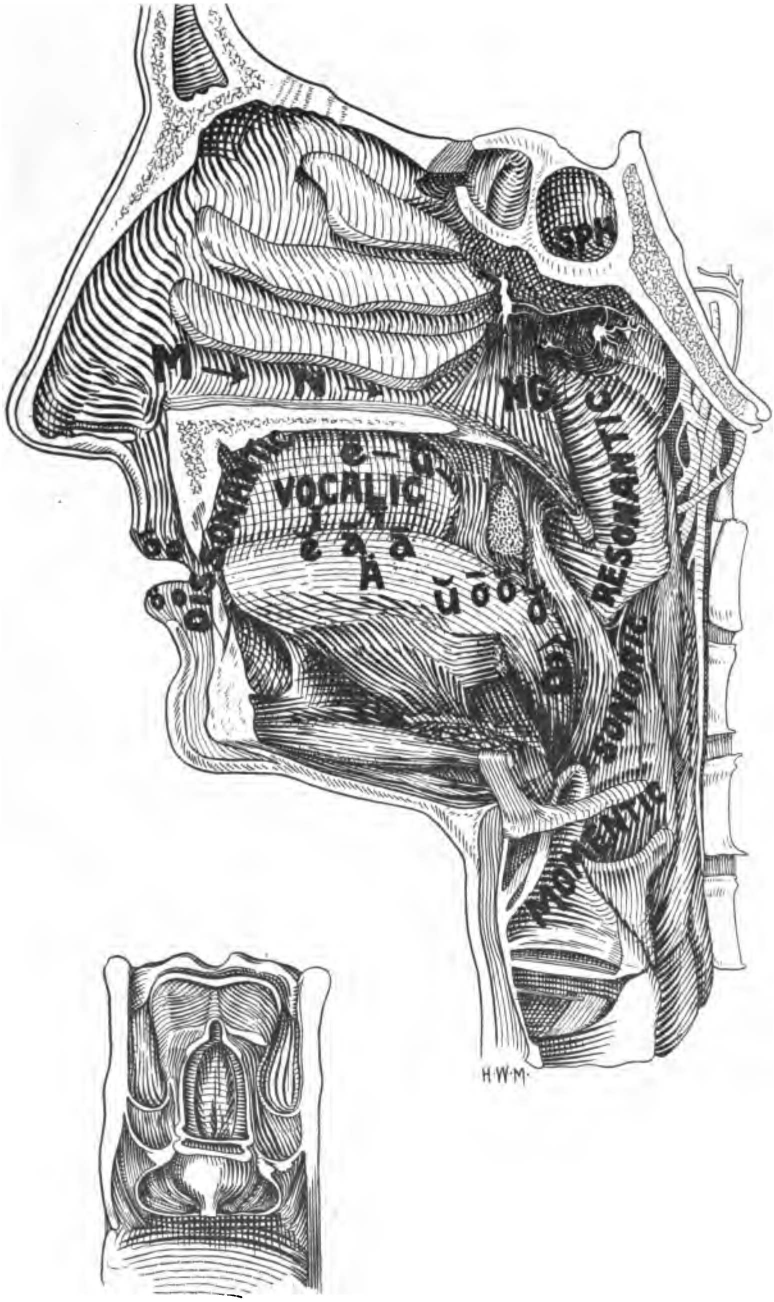


Fig. 11.
Vowel Chart

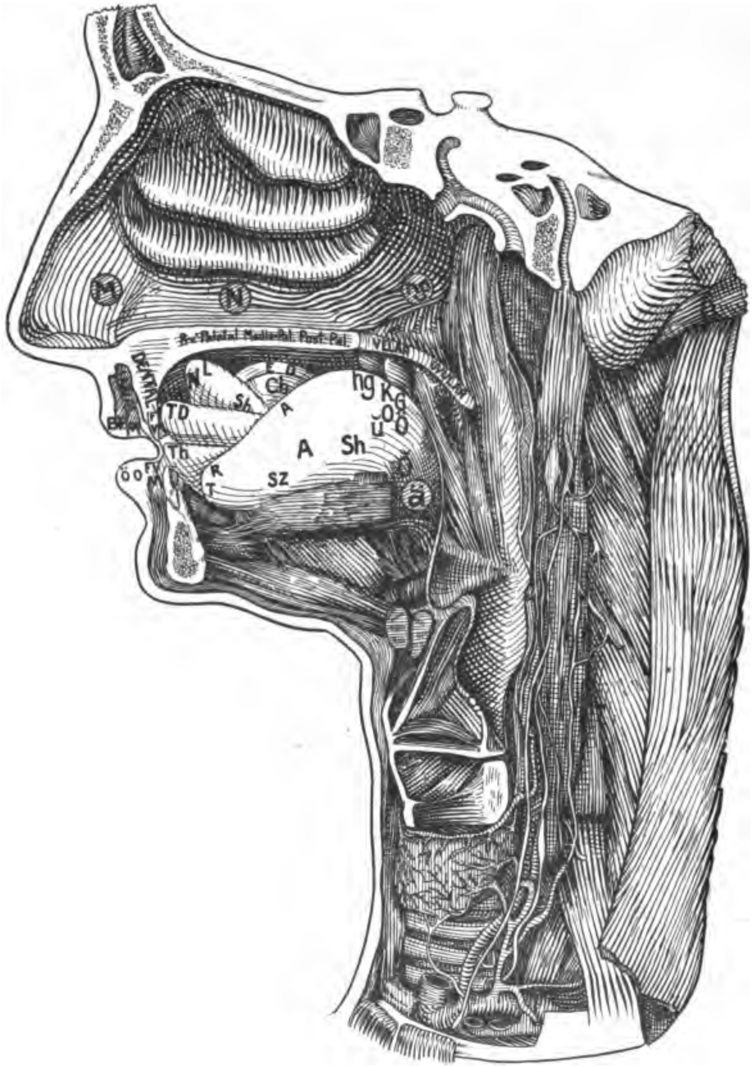


Fig. 12.
Consonant Chart

In the nose is the space of Nasal Resonance, and overtones, where the speech elements M, N and Ng are produced.

Above the tongue is the Vocalic Region, while the lips, teeth and tongue form the Nonsonantic moulders of positions for vowel-elements when affected by the so-called vocal labyrinth.

Fig. 11 shows the exact location where each speech-element of vowel-value is formed, by the positions of the organs.

Fig. 12 shows where initial consonant-sounds are made by the action of the organs. Both these illustrations show that speech-elements are not adventitious, but organic, depending on the structure for their functioning.

Fig. 13 gives an external view of the chief muscles of the Vocatorium, or Vocalion.

These muscles, it must be remembered, have many duties. To aid in mastication and swallowing they must act mutually with muscles of face, throat, and thorax. They must also act with these as well as with muscles of abdomen and diaphragm, to aid in breathing in phonation.

None of these muscles of the Vocatorium are involuntary. They either act voluntarily, or from habits, and in groups as autonomies, to carry on their functions, as we have already shown.

The voice being absolutely automatic, it is not alone an unnecessary but a wrong principle, to describe individual action of muscles, unless they govern the vocal autonomies, for vocal art is based on the explanation of its autonomous action by its nerve-supply and not in its muscular action *per se*.

Figs. 14 and 15 give different views of the Pneumatic Autonomy. In the first, a front view of the normal lung-expansion is shown, the lobes of the lungs falling tent-like over the heart, with the diaphragm separating them from the stomach, liver, etc.

The next illustration presents a deeper front view of the lungs, with the edges of the diaphragm in two positions representing its different curves, the upper or double arch of normal exhalation, and the lower, single arch or

dome of normal inhalation. Diagrammatic outlines represent the rib cartilages.

In normal inhalation all the ribs expand, enlarging the chest cage, while at the same time the diaphragm contracts, moving downward, and slightly distending the abdomen.

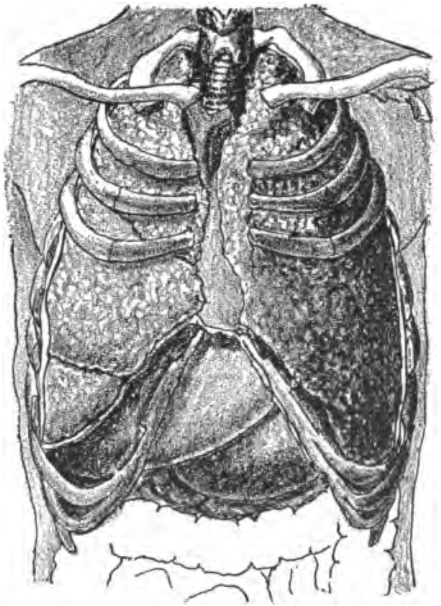


Fig. 14.

In normal exhalation the entire thoracic cage diminishes somewhat, while the diaphragm regulates and is pressed upward by abdominal and lumbar muscles.

In the latter case it is a passive organ; in the former, active.

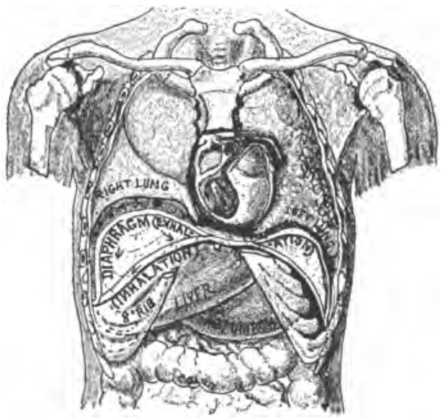


Fig. 15.

There are several localized forms of breathing, as, for instance, clavicular, when during exhalation the upper rib-region is relaxed while the lower, with the diaphragm, is held firmly. Thoracic breathing occurs when during exhalation the entire rib-region relaxes, bowing the ribs obliquely downward, the diaphragm remaining inactive. When during exhalation the entire rib-region is held firm and the diaphragm suffered to relax,

Fig. 13.
Muscles of Vocatorium

its arches rising, and the pressure of abdominal muscles is exerted on the viscera, diaphragmatic breathing will ensue.

Breathing adjusted to voice-production will be presented later. Meanwhile it is well to note that breath-control cannot be gained through any parts above the vocatorium. It is a matter entirely for infra-laryngeal units.

The phrenic nerve governs the diaphragm and is its principal nerve-supply, by which it receives its stimulation. The phrenic nerve has a most important functioning with the abdominal muscles which have positive control of the energy of greatest magnitude, yet this nerve is the greatest of all affiliators, synchronizing every function of nutrition, inhibition and sympathetic relationship of the chest where our pneumatic unit is situated.

Therefore, the clutch which is produced (namely, by the abdominal muscles) plus the action of the lower intercostals and the dipahragm for the muscular regulation, gives a sympathetic control over everything, and logically is the only natural way for harmonizing breath.

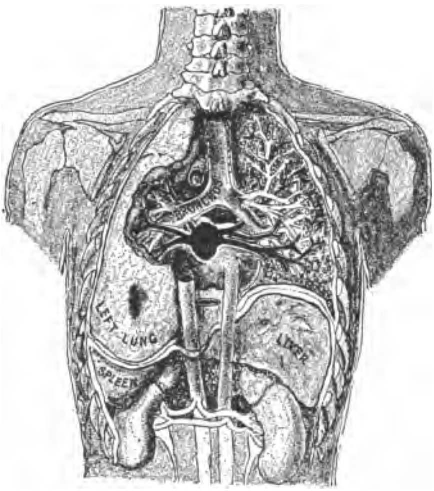


Fig. 16.

Fig. 16 is a back view of the Pneumatic Autonomy with the ribs, spinal column, and part of the lungs dissected away, revealing trachea, bronchi, pulmonary veins and heart. Also the contours of the diaphragm in the deep back are shown.

Combining our five cell-like units into one giant cell, we find that this extends from the naso-oral sphincter to the *sphincter ani*, with a physiological control that depends on poles with their contrapuntals at five points of poise: at the bridge of the nose; at arch of hard

palate; at crico-thyroid notch; at breast-bone; and at navel. These offer a combined point of poise, a mechanical centre of resistance, between the diaphragm and the umbilicus over the great sympathetic plexus.

Fig. 17 shows this combination, the long arrows indicating the poles, or axes of power. These are regional bases of forces, while the short arrows crossing these, point the direction of the thrust, or momentum, the focuses being at the zero signs.

The first o-arrow is the Resonantic pole, equated by Meckel's and Otic ganglion, and the spinal accessory nerve. The second is the Oral or Vocalic, governing the vocalic region and aperture by the pharyngeal plexus and spinal accessory. Third is the Momentic and Sonoric pole, governing these regions and apertures by superior and recurrent laryngeal and pneumogastric nerves. The fourth shows the Pneumatic pole, centering in cardiac and bronchial plexuses. Fifth comes the Dynamic Resistance pole, governed by lumbar nerves, and the pelvic and sacral plexuses.

Passing obliquely downward from the upper part of the shoulder through the solar plexus to the lower part of the abdomen is the axis of Resistance. The poise of the torso swings on this. Normal poise is the perfect balance between pneumatic region and that of Dynamic Resistance.

Fig. 18 shows the great external muscles of the head and trunk, and these exert a strong influence on the autonomies.

Nerve-government of voice in autonomies.

The nerve-government of phonation, considered by autonomies, begins with the sympathetic plexuses of the abdominal viscera and the control of the anus. The phrenic nerve is the controller of the diaphragm. In its course it passes to the pneumogastric nerve, and receives branches from the spinal accessory, hypo-glossal, cervical and thoracic nerves, of the Pneumatic Autonomy.

Pneumatic and momentic.

The Momentic Autonomy, in its relation to voice, is so absolutely under the control of the spinal accessory nerve that when this nerve is severed tone stops, although the laryngeal actions of respiration still go on under the influence of nerves derived from the facial, hypo-glossal,

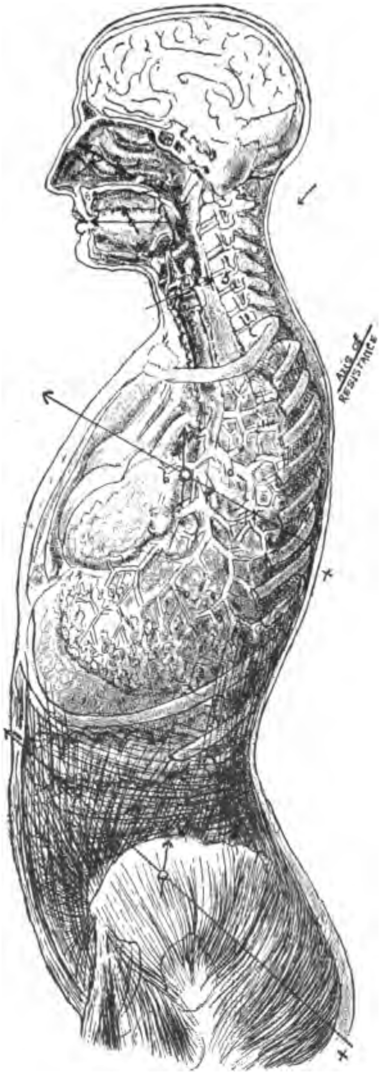


Fig. 17. Poles of Power.

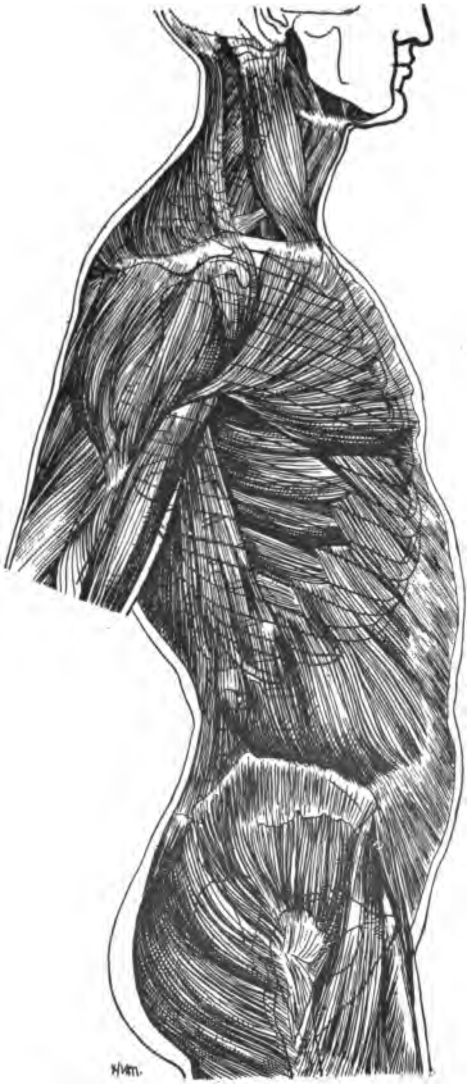


Fig. 18. Muscles of Head and Trunk.

and cervical nerves through the pneumogastric, which is a nerve of the first magnitude concerned in motion, sensation, nutrition and inhibition. This pneumogastric is joined with the internal, or anastomotic branch of the spinal accessory, a portion of which appears as a part of the inferior, or recurrent laryngeal nerve.

The inferior laryngeal, the nerve source of voice.

The vagus or pneumogastric nerve arises from the tenth cervical, originating at the fourth ventricle of the brain belonging to pons and medulla, and is distributed to the ear, pharynx, larynx, heart, esophagus and stomach. At present it is of supreme importance to us in its appearance in the inferior laryngeal, since this is the source of energy that manifests itself in voice. This supplies all laryngeal muscles, excepting the crico-thyroid and laryngeal mucous membrane. It positively governs that position of the arytenoids which holds the glottis open for vocal use. Sensation, however, is supplied to the mucous membrane of the vocal folds by the superior laryngeal nerve. It is also the inferior laryngeal nerve that innervates the thyro-arytenoids.

Widely governed also are Sonoric and Resonantic autonomies in their nerve-controls.

Communicating with facial and pneumogastric, the glosso-pharyngeal nerve sends one branch to the back part of the tongue, the pillars, and soft palate; another to diagastric, stylo-pharyngeus, and stylo-glossus; while another branch, together with branches of the pneumogastric, run to superior and middle constrictors. The inferior constrictor is in the province of the Momentic autonomy. The muscles governed by these nerves draw the tongue backward and upward, and elevate larynx and pharynx, closing, opening and governing the Sonoric and Resonantic regions as two separate autonomies. Although the glosso-pharyngeal is chiefly a nerve of sensation and not of motion, branches of it received from the facial, spinal accessory, and cervical nerves, act as motor nerves, either under the suggestion from sensation, or under the command of intellect or will.

Vocalic and non-sonantic.

In Vocalic and Non-Sonantic Autonomies, the hypoglossal nerve sends branches to the stylo-hyoid, hyo-glossus,

and infra-hyoid muscles, and to other muscles beneath the tongue. Arising from the medulla, it enters the substance of the tongue as control, between mylo-hyoid and hyo-glossal muscles, governing articulate speech in association with the facial nerve which acts on cheeks and lips. The hypo-glossal also acts, through the great superficial petrossal nerve, on the soft palate and uvula, through the levatores palati muscles. By its communication with the pneumogastric and glosso-pharyngeal nerves, the mouth and tongue are brought into vocalic relations with the lungs and the rest of the all-inclusive organ of voice.

With this regional distribution of labor established through autonomies, the muscle-controls of voice, as these occur in groups, must next be studied.

Fulfillment of premises.

From this general survey it will be seen that our premises are fulfilled in so far as voice is automatic, through this series of coördinated units; sphincteric, from anus to lips, and based on the laws of nature. It is analogous to the principle of thought, of life, in the intake, digestion and outgo of human conception. If followed out, it will be seen that the voice idea is like unto conception; that, by automatic contraction, the formless and unborn mass of breath is fashioned in the vocal womb into a human reproduction of a divine image—voice!

CHAPTER V

The Muscle-Control of Voice

Voice is a form of energy, produced by a series of coördinated muscle-actions, under nerve-control, and operating in autonomies so as to produce sound according to the laws of kinesis (motion).

Vocal Art-Science demands a detailed study of these muscle-groups with their innervation, so as to show where the energy concerned in producing voice is developed.

The vocatorium, including laryngeal and supra-laryngeal apparatus, with its relation to all associated parts, and the muscle-controls that implicate the whole body as an organ of voice, must be taken into account, and will now be considered in this light.

Muscles.

We have spoken of muscles as organs of voluntary and involuntary motion, of the origin of the nerve stimulus under which muscle power is exerted; and of the act this activity is required to perform. We have considered the muscles in groups when concerned in the act of phonation. It now is necessary to examine these groups individually, and to consider the several muscle-members of which they are composed.

Muscles must be observed from the standpoint of mechanics, with reference to the parts of the body that, by contraction, they are required to move. Where they are attached to two different points, the one where the fibres are more spread is called the origin; the other, where the fibres are more closely bound, the insertion. Usually the greater movability is at the latter point. The swell of the muscle is called its belly. Two such enlargements in one muscle separated by a tendon causes this to be termed digastric. Muscles generally do their work in pairs, symmetrically employed. Two pairs working in opposition to bring about a motion are said to be antagonistic. Muscles near the surface are called extrinsic or external; those hidden within a construction, intrinsic, or internal.

Certain muscles send fibre-branches to two points of insertion, external and internal, thus governing two movements, one relating to a whole construction, the other to a part. Consideration must also be given to whether muscles belong to a single construction, or whether they are common to more than one.

Muscles are named for their form and configuration, as, for instance, serratus, toothed, like a saw; they may be named for their office as are the rib-raisers, *levatores costarum;* and for their bases of attachment, as are sterno-hyoid, crico-artyenoid.

Organs of motion, or work accomplished by movements, these must be referred to nerve-centres either cerebral or sub-cerebral.

Sub-cerebral centres initiate movements connected with animal existence and organic life, such as automatic breathing; and in phonation all manifestations of sound that express emotions common to humanity, such as moaning, shrieking, and shouting, are likewise of sub-cerebral origin. The particular movements requisitioned in speech and song are primarily voluntary, and therefore to be referred to cerebral centres.

The correlation of forces which results in the standardization of Vocal Art-Science is difficult to understand, because it requires a lifetime of specialism to determine the accuracy with which these forces sympathize with each other. In fact, it has been impossible for one person to do this; but with the wonderful data that have been gathered from all parts of the world, the writer has formulated his conclusions regarding the nature of these forces into positive rules of procedure, from which he has developed a true and definite standard of Vocal Art-Science. It can be shown that the empiricism of the old masters was very nearly perfect. It can be proved to what degree it was correct and how far it went wrong. In other words, Vocal Art-Science takes the rules of empiricism and verifies or disproves them by synthesis. Vocal Art-Science is a codified standard for voice-production; and with an answer to every question, even the latest, the stumbling-block of all investigators who have been trying

to substantiate the relationship between physical and psychic voice, namely:

> What is the medium between the volition and the activation of the cortex?

It will be found on the left side of the parietal-temporal lobe, where are located the several speech-centres—motor, sensory, and visual; their point of kinesis being the same for pitch, the same for resonance, and the same for power or energy throughout the entire body. The cells in the speech-centres are activated by associated neurons, which bring to the tracts the impetus needed to carry the required power from the primary cell to the lateral tract. It is a well-known fact that you can cut one of these lateral tracts of the larynx, yet not check the voice, but if you cut both tracts you will surely check it. Thus the impetus from the brain seems to act by sympathy; so that this impetus (or idea, if you prefer that term) forms the link between the volition and the activation of the cortex.

To recapitulate this important phase of Vocal Art-Science: In the brain, and situated on the left side of the temporal-parietal lobe, is the musical centre—the voice-nucleus—in which reside every movement and motion that make voice arise. The initial impulse occurs in the brain and from there it is carried by neurons (cells with little tentacles attached to them) throughout the entire body. These cells of the brain radiate energy through the neurons by their tentacles which connect up all sides through activation of the cortex, especially on the left side, where the musical centre is situated. By analogy it becomes clear how every part of the body concerned in voice-production and every physical sense of voice joins in the act. It is by their response, through kinesis, to the originating impulse, which may be said to move along the boundary line between violition and activation, that voice is developed.

Breathing in itself is a natural and automatic act, for we breathe by the mere fact of being alive; yet in phonation it is deliberate and studied—in other words, the welding of art and science. It is the regulation of auto-

matic breathing, first by the will, then from force of habit. To acquire the art we must study the mechanics of the organic, the natural and automatic act, in order to regulate it so that it may become the motor power of song.

Breathing or respiration, as such, consists of two automatic movements, the intake and the output of air; inspiration or inhalation, and expiration or exhalation. The intake comes about by atmospheric pressure, by way of mouth and nose. Expiration is merely passive, produced by the elasticity of the lungs and the resilience of the ribs, the air passing through trachea and larynx, past the epiglottis into the pharynx, where the current of air is divided and conveyed out, partly by the mouth and partly through the nasal cavity, by way of the nostrils.

The inspiratory movement consists in the contraction and lowering of the diaphragm, and in the expansion of the ribs, and retraction of the abdomen.

Inspiratory

Muscles	*Nerve-Supply*
Diaphragm	Phrenic nerve.
Intercostals	Intercostal nerve.
Lavatores costarum	Intercostal nerve.
Cervicalis-ascendens serratus-posticus-superior	Exterior branches of posterior divisions of cervical nerves.
Scalenus anticus Scalenus medius Scalenus posticus	Lower cervical nerve.
Levator-anguli-scapuli	Fifth cervical nerve and deep branches from the cervical plexus.
Trapezius	Spinal accessory nerve, or eleventh cranial, and deep branches from cervical plexus.
Serratus-magnus	From the posterior or long thoracic nerve.
Pectoralis minor Pectoralis major	From the anterior thoracic branches of the brachial plexus.
Latissimus-dorsi	Long subscapular nerve.

Expiratory

Muscles	*Nerve-Supply*
Intercostals	Intercostal nerve.
Obliquus-abdominis-externus	Lower intercostal nerve.
Obliquus-abdominis-internus	Ilio-hypogastric and ilio-inguinal nerves.
Rectus-abdominis	Lower intercostal ilio-hypogastric and ilio-inguinal.

EXPIRATORY—*Continued*

Muscles	*Nerve-Supply*
Transversalis-abdominis	Lower intercostal nerve.
Triangularis-sterni	Intercostal nerves.
Quadratus-inferior	Filament from anterior branches lumbar nerves.
Serratus-posticus-inferior	External branches of posterior division of lower dorsal nerves.
Sacro-lumbalis. Portions of erector spinali. Ilio-costalis. Accessorius-ad-ilia-costalis.	External branches of posterior division of lumbar and dorsal nerves.

The muscles proper to the larynx alone have two offices: To control the laryngeal entrance, and to provide for tensing the vocal folds. These two offices are not wholly independent one of the other. Our main concern, however, is with their latter function. Muscles that associate the larynx with other parts of the body are required to hold it in the best possible position for the vocal act, namely, against the fifth cervical vertebra, at which point the longus colli muscles divide to make a place for it.

These muscles of fixation are the stylo-pharyngeus, sterno-hyoid, and omo-hyoid, all in pairs.

The omo-hyoid (from the Greek *omos*, a shoulder) extends from underneath the body of the hyoid or tongue-bone, and passes downward under a muscular loop which secures it to the clavicle. This muscle aids strongly in pulling the larynx down and backward.

When the tongue and chin muscles overact, this muscle will not be able to do its part in keeping the larynx in place.

Chorda Tympani, branch of facial or seventh cranial nerve.	1. Lingualis. 2. Post belly of digastric. 3. Stylo-hyoid. 4. Levator palati (elevator of palate). 5. Azygos uvulae.	Through Vidian Nerve.

Function: To depress side and extremities of tongue, giving it a convex outline; or depressing the dorsum, giving a concave outline, thereby influencing the voice. Nos. 4 and 5 lift soft palate and give firmess to converging muscles.

The sterno-thyroid anchors the larynx to the breastbone through its attachment to the thyroid cartilage

above, and below to the posterior portion of the first bone of the sternum.

The muscles of fixation, by contacting the larynx or voice-chamber with the spine and sternum, impress the whole framework of the body, as a resonator, into the service of voice, by incorporating sympathetic vibrations.

The muscles of the larynx proper control the vocal lips and valve as tensors and relaxers; in other words, as closers and openers. These are the factors that, by responding with opposition to air-pressure from below, produce the vibrations that are the physical cause of voice.

Tensors. The tensors or cord-stretchers are the crico-thyroids. Each of this pair appears as a triangular muscle with its origin in the anterior surface of the larynx at the cricoid cartilage, and running obliquely to insertions both internally and laterally, at the anterior margin of the thyroid wing on the corresponding side.

Relaxers. The relaxers are the thyro-arytenoids. This pair presents the largest muscles of the larynx proper. Each appears in two layers, external and internal. The external is in three divisions, with bases of attachment at the thyroid cartilage and the arytenoid. The internal is pyramidal in form, having its origin in the angle of the thyroid, and insertions at the apex, with the upper and lower surface of the vocal process on the corresponding side. These muscles border both inferior and superior vocal folds, and form a large proportion of the substance of them.

The glottic valve-openers are the crico-arytenoids (postici), a pair of triangular muscles with origin at the posterior surface of the cricoid, and insertion at the posterior lower margin of the arytenoid on the corresponding side.

Valve-closers. The principal agent in closing the glottis is the single muscle, the arytenoideus, with fibres running transversely in three directions, rendering it a tripartite muscle, with points of attachment at the arytenoids.

Aiding this in valve-closing is a pair, the crico-arytenoids (laterals), which are the smallest muscles of the larynx proper, with origin at the cricoid, ascending obliquely to insertion at the arytenoid.

Tensing or cord-stretching may be resolved into three parts: The adjustment of the relation between thyroid and cricoid cartilages; the consequent change of position of the arytenoids; and the specific tensing of the vocal folds required for vocal pitch. This last aspect may for the present be waived. Tensing for phonation regardless of pitch is affected by the upward pull of the cricoid cartilage, and the downward and inward pull of the thyroid cartilage, by the crico-thyroid muscles. This upward tilt of the cricoid ring in front causes its posterior portion, with the superimposed arytenoids, to tilt back and down, stretching and lengthening the vocal folds.

Valve-closing action of the arytenoids.

The glottic valve-closer, the arytenoid muscle, by contraction, draws back the muscular process of the arytenoid, bringing the vocal processes nearer together, closing the *rima.*

The movement of the arytenoids upon the cricoid is in three parts: A rotation that brings the vocal processes close together; a hinge-action that moves these processes up and out, raising and opening the glottis, or down and in, with contrary effect; and last, a sliding action by which the two cartilages approach each other.

Abductors and adductors.

All these intrinsic muscles of the larynx save two are adductors; that is, they tend more or less to contract the space in the glottis. Two, the crico-arytenoids (posticus) are abductors tending to open it. The adductors are nine in number: Two crico-thyroids; two lateral crico-arytenoids; the threefold arytenoid, and the two thyro-arytenoids. This anatomical arrangement is easily remembered by recalling that in a state of rest the glottis is open, while in phonation it is more or less closed. Nine muscles, therefore, control the glottis in its working periods and two in its state of rest, as the prisms of the eye do for sight.

The nine controllers of glottic space in action.

To this group of larynx muscles we must now add those which close or narrow the upper laryngeal opening, by attachments with the epiglottis, and which concern themselves mainly with deglutition. They are the aryteno-epiglottideus, superior and inferior, in pairs, and the thyro-epiglottideus, in pairs.

Seven pairs.

One single.

Considered with regard to their nerve-supply the full quota of larynx muscles is as follows:

Muscles of Larynx

		Nerve-Supply	
Seven Pairs.	Acting on vocal cords; four pairs and one single muscle.	1. Crico-thyroid. 2. Crico-arytenoid posticus. 3. Crico-arytenoid lateralis. 4. Thyro-arytenoid. — Recurrent laryngeal nerve. 5. Arytenoideus (single).	1. Crico-arytenoid posticus. 2. Crico-arytenoid lateralis. 3. Thyro-arytenoid.
One Single.	Acting on epiglottis; three pairs of muscles.	1. Aryteno-epiglottideus superior. 2. Aryteno-epiglottideus inferior. 3. Thyro-epiglottideus.	4. Aryteno-epiglottideus superior. 5. Aryteno-epiglottideus inferior. 6. Thyro-epiglottideus. 7. Crico-thyroid. / 8. Arytenoideus. — Also by superior laryngeal.

Function: The former group being attached to the vocal cords control phonation, and the latter being attached to the epiglottis causes the epiglottis to be compressed or raised.

Individual action given below:

Muscles which stretch the vocal cords	The crico-thyroid muscles.
Muscles which relax the vocal cords	The thyro-arytenoid muscles.
Muscles which open the glottis	The crico-arytenoid posticus (crico arytenoid laterales).
Muscles which close the glottis	The arytenoideus.
Muscles compressing superior opening of the larynx in deglutition	Aryteno-epiglottideus superioris.
Muscles depressing the epiglottis during the act of deglutition	Thyro-epiglottideus.
Muscles compressing the sacculus laryngis	Aryteno-epiglottideus inferioris.

	Name of Muscle	*Nerve-Supply*
External larynx muscles causing fixation.	1. Sterno-thyroid. 2. Stylo-pharyngeus.	1. Infra-hyoid group descendeus noni (loop). 2. Glosso-pharyngeal branches of pharyngeal plexus.
External larynx muscles causing cord-stretching.	1. Palato-pharyngeus. 2. Sterno-hyoid.	1. Palatal branches of Meckel's ganglion. 2. Descendeus noni (loop) infra-hyoid group.

Functions: Muscles causing fixation of the larynx hold the larynx against the fifth cervical vertebra, where the longus colli muscles lie apart to make room for the close contact of the larynx with the spine. This position of the larynx imparts the greatest resonance to the voice, since the vibrating larynx is in close contact with the bony frame of the body.

The muscles of cord-stretching pull the thyroid cartilage from the back upward and forward, and from the front down and backward, swinging the thyroid cartilage in its socket on the cricoid cartilage below, thus stretching the vocal bands from the arytenoid to the thyroid, and the latter action gives great spontaneity of delivery.

When these two actions, fixation and cord-stretching, are well adjusted a voice has the principal requisites for fine use.

The palato-pharyngei, extending to uvula and soft palate from the thyroid at its upper posterior edge, pull this up and forward. The levatores-palati, rising from the uvula to petrous bone above, maintain this laryngeal position. By this up-and-forward pull the palato-pharyngei, working in antagonism to the sterno-hyoidei, as noted, anchored the larynx by the anterior portion of the thyroid below, tilts the thyroid in its cricoidal socket, tensing the vocal folds, and changing the boundaries of pharyngeal spaces throughout the entire voice range.

Pharynx Muscles.

The pharynx muscles are in part agents in deglutition. In phonation the superior constrictor affects resonance, as it forms the posterior wall of nasal and oral cavities. This

brings us to the muscle-controls of the Articulate and Resonantic Units.

The vocatorium may be divided into laryngeal and supra-laryngeal areas. So far we have discussed muscle-controls belonging exclusively to the former. It now is in order to consider these in relation to the supra-laryngeal influences, the nasal, oral, maxillary, hyoid, pharyngeal and palate groups. The palate muscles assist the processes of deglutition and of swallowing. In phonation they are concerned in changing the boundaries of air-chambers, and coöperatively in cord-stretching. These muscles are:

Muscles of Palate

		Nerve-Supply	
Five Pairs.	1. Tensor palati. 2. Levator palati. 3. Palato-glossus. 4. Palato-pharyngeus. 5. Azygos uvulae.	Glosso-pharyngeal; also external and recurrent laryngeal nerve.	Inferior constrictor.

Functions: Besides assisting in the process of deglutition, they cause changes in size of opening buccal and pharyngeal cavities. The palate group as a whole forms the upward influence which swings the thyroid cartilage forward on the cricoid cartilage for stretching the vocal cords.

Muscles of Pharynx

		Nerve-Supply
Three Pairs.	1. Superior constrictor. 2. Middle constrictor. 3. Inferior constrictor.	Glosso-pharyngeal, branch of ninth cranial nerve and pharyngeal plexus.

Functions: In part, muscles of deglutition; the superior constrictor being an important agent in singing, since it forms the posterior wall of the nasal and oral hollow space, or resonance-chamber of the voice.

Muscles of the tongue.

The substance of the tongue is composed of five muscles. Its intrinsic fibres are derived from the linguals; the extrinsic fibres, connecting it with other structures, are the hyo-glossus, genio-glossus, stylo-glossus, all in pairs. The hyo-glossus, which fastens the tongue at the back to the

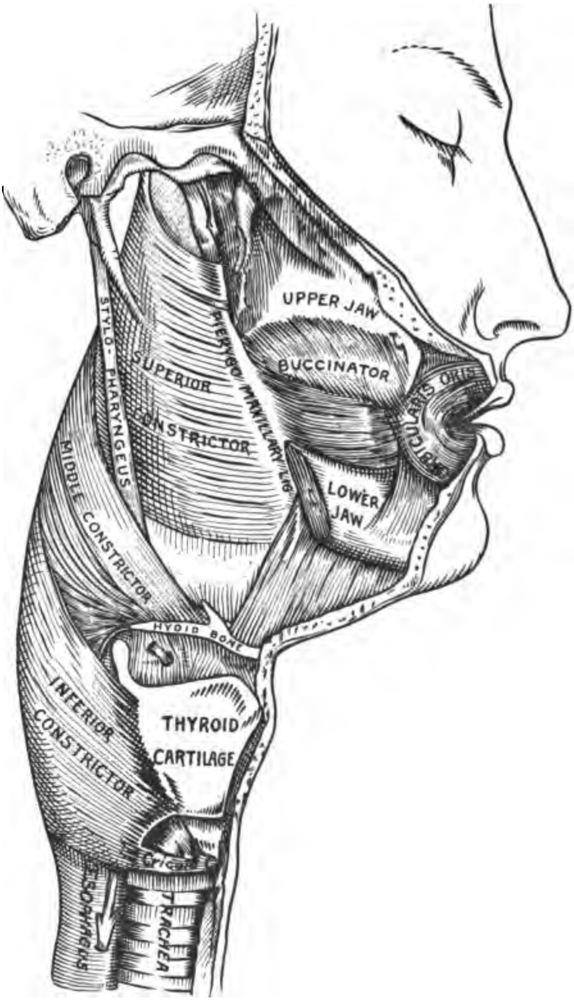


Fig. 19. Muscles of the pharynx. External view.

hyoid bone, may seriously affect cord-stretching, as any tightness in it prevents the thyroid's swing upon the cricoid.

The tongue muscles must also be studied in connection with those of the palate and the chin. Grouped according to their nerve-supply the former are:

Sub-Maxillary or Stylo-Hyoid Group

		Nerve-Supply	
Three Pairs.	1. (Posterior belly) or (digastric) stylo-hyoid. 2. Stylo-glossus. 3. Stylo-pharyngeus.	Glosso-pharyngeal branch of ninth cranial nerve and pharyngeal plexus.	1. Stylo-pharyngeus. 2. Superior constrictor. 3. Middle constrictor. 4. Inferior constrictor.

Branch from the otic ganglion... 1. Tensor palati (stretcher of palate).....

Palatine branches of Meckel's ganglion............ 1. Palati-glossus. 2. Palato-pharyngeus.

Function: Changes position of the tongue and enlarges the cavity of the pharynx. The latter change is brought about by the stylo-pharyngeus. Both groups govern deglutition, the process of propelling food and liquid into œsophagus and preventing their entrance into larynx.

The muscle-groups involving tongue and chin, and also raisers of the soft-palate, are the genio-hyoids (from the Greek *geneion*, chin).

Supra or Genio-Hyoid Group

		Nerve-Supply	
Six Pairs.	1. Anterior belly of digastric. 2. Mylo-hyoid. 3. Genio-hyoid.	Mylo-hyoid nerve.	1. Digastric, anterior belly (double-bellied). 2. Mylo-hyoid.
	4. Genio-hyo-glossus. 5. Hyo-glossus. 6. Lingualis.	Hypo-glossal or twelfth cranial nerve.	1. Genio-hyoid. 2. Genio-hyo-glossus. 3. Hyo-glossus. 4. Stylo-glossus.

Of these the mylo-hyoid demands special attention in phonation. This pair of muscles form the floor of the mouth, and fastening from the whole edge of the lower

jaw to the body of the hyoid bone, the fibres meet in the centre of the chin.

These muscles influence voice-production by changing the outline of the tongue, rendering it concave by depressing its ridge or dorsum; or, by depressing it at sides and extremity, convexing its form. The palate-raisers have already been mentioned as important in fold-stretching.

Under this heading the principal fact to bear in mind is that the palato-pharyngeus bears to the voice the same relation that the piano-frame does to the piano.

The jaw muscles are the maxillaries, from the Greek *maxa*, a kneaded mass.

Maxillary Group

		Nerve-Supply	
Four Pairs.	1. Temporal. 2. Masseter. 3. External pterygoid. 4. Internal pterygoid.	Inferior maxillary division of the fifth cranial nerve.	1. Temporal. 2. Masseter (masticator). 3. External pterygoid. 4. Internal pterygoid.

Function: Mastication. The external and internal pterygoids alternately carry the lower jaw from side to side, and all conjointly cause the lower jaw to move forward and backward on the upper jaw, as in chewing food. These muscles are not supports for the singing voice. Sometimes resorted to with disastrous results.

The muscle-controls of Articulate and Resonantic Units are the nasal and labial.

Labial Group

Nine Pairs.	Upper Lip.	1. Levator labii superioris proprius. 2. Levator anguli oris. 3. Zygomaticus major.
	Angle.	4. Zygomaticus minor. 5. Buccinator. 6. Risorius santorini.
	Lower Lip.	7. Levator menti. 8. Depressor labii inferioris. 9. Depressor anguli oris.
One Single.		Orbicularis oris (1 single).

The function of these may be considered with those of the nasals.

Nasal Group

Four Pairs:
- Pyramidalis nasi.
- Levator labii superioris.
- Alaequae nasi.
- Compressor naris.
- Depressor labii superioris et nasi.

Nerve-Supply
Infra Orbital, branch of the facial or seventh cranial nerve.

1. Pyramidalis (dilator of the nose).
2. Levator labii superioris alaequae nasi (elevator of upper lip and ala of nose).
3. Compressor naris (compressor of the alae of nose).
4. Depressor labii superioris et nasi (depressor of upper lip and nose).
5. Levator labii superioris (proprius) (elevator of upper lip).
6. Levator anguli oris (elevator of the angle of the mouth).
7. Zygomaticus major (greater cheek muscle).
8. Zygomaticus minor (lesser cheek muscle).
9. Levator menti (elevator of upper lip).
10. Depressor labii inferioris (depressor of lower lip).
11. Depressor anguli oris (depressor of angle of mouth).
12. Orbicularis oris (constrictor) circular muscle of mouth.
13. Buccinator (trumpeter compressor of cheek). Also by buccal branch of the inferior maxillary nerve.
14. Risorius santorini (smiling muscle). Also by superior maxillary branch of the facial.

Function: Give expression and assist in mastication, talking and singing. Particularly are these muscles useful to the singer in enunciation. The buccinator, pressing the cheeks inward,assists in these functions; also in the acts of blowing and sucking.

In addition to these special-muscle-sets, all the great external muscles influence phonation.

If the muscles which support head and shoulders are overtensed they will constrain the vessels and organs of the vocatorium and defeat pure tone-production. Disproportionate contraction of the muscles which move or fix the hyoid bone will swing the Momentic Autonomy out of normal alignment. If these same muscles are devitalized and flaccid they may so yield to the influence of the styloid and palatal muscles as to throw the vocal organs into wrong relations.

The great muscles that play on ribs, sternum, clavicle, and shoulder girdle, directly affect the Pneumatic Autonomy. The abdominal muscles, as we know, are all important in exhalation.

Balance of the body: poise.

Bodily poise causes the external muscles of the back to aid the deep throat muscles in contacting the larynx with the fifth cervical vertebra, increasing vocal volume, and enhancing quality.

The balance of the body on the pelvic frame, the flexible normal curves of the column, curves that give ease and grace to the body, are chiefly sustained by the erector spinali. Moreover, on the tonicity of the muscles depends the relative altitude of the whole rib-cage; if allowed to become relaxed and habitually elongated, the freedom and responsiveness of the chest will be proportionately diminished, the normal balance of the parts swinging on the axis of resistance will be destroyed, and beautiful, expressive poise will be impossible.

Muscular tonicity.

Muscular tonicity and normal poise, these are primary requisites in Vocal Art-Science.

John Tyndall (1820-1893).

Voice, analyzed into special muscle-controls, and synthetized into an automatically produced form of energy, must next be considered as an expression of what Tyndall has called "the most perfect, the most beautiful, of musical instruments."

CHAPTER VI

The Vocal Instrument

Voice is the product of "the most perfect, the most beautiful, of musical instruments." The precise nature of this instrument has formed the quest of truth-seekers, whether empiricists or scientists, from Hippocrates, four hundred years before the Christian era, to such contemporaneous authority as Dr. Marage, of Paris; Oertel, inventor of the stroboscope; Garcia, of laryngoscope fame, and others. **Hippocrates, 400 B.C.**

In 1869, in the memoirs of the Paris Academy of Science, Dr. Longet published an abstract of the several theories put forth during the century preceding Helmholtz as to the cause of voice. **François A. Longet, 1869.**

Briefly enumerated from his text, these begin with Dodart, who between 1700 and 1707 published two or three treatises on the subject, in some respects self-conflicting. None the less, to him belongs the credit of understanding the general trend of vocal phenomena, and of having clearly indicated points still awaiting solution. **Dennis Dodart (1684-1707).**

Ferrein in 1814 advances on Dodart by attributing tonal changes not alone to change in the tension of the glottis lips. Also to him belongs the credit of being first to support assertion by precise experiment, and to claim for the larynx the properties of both a stringed and a wind-instrument. **Antoine Ferrein (1693-1769).**

Only Cuvier's great name permits a mention of his theory put forth in 1807, in effect that the glottis sways like a reed, determining the harmonics of fundamentals which are produced as in the tube of a wind-instrument. In addition to this he states that the larynx falls as we sing an ascending scale, whereas, as can readily be shown, it rises; while a voice can make all the sounds within its compass, not all these are harmonics of the fundamental tones. **Georges Cuvier (1769-1832).**

About the same time, Dutrochet enunciated a theory closely resembling that of Ferrein; but a denial of all **René J. Dutrochet (1776-1847).**

supra-laryngeal influence is difficult to understand in so competent an observer.

Liscovins, in 1814, explained voice as vibration from molecular friction through the compression of air in the glottis passage. Later he attributed to the ventricles the principal part in voice-production.

Magendie, in 1816, propounded a theory adopted by Biot, comparing the vocal apparatus to a reed-instrument; but, with all consideration for these distinguished names, physiology repudiates this. In an organ, the shorter the valve the higher the tone, while in the larynx the width of the folds which would correspond to this, increases with a rise of tone.

Marie G. A. Savard (1814-1881)

Savard, in 1825, formulated an entirely new theory, uniting larynx, pharynx and mouth into a conical pipe, with the glottis for valve, the ventricular bands functioning like the organ-pipe beveling, and the sound produced in the ventricles being reinforced above, but including the whole vocal gamut. The lack of similarity between the superior laryngeal ligaments, and the requisite beveling, however, renders this view untenable.

Gerdy, in 1830, offered another theory which experiment fails to support. Nevertheless, to him is due the credit of being first to describe the form assumed by the isthmus of the gullet, during phonation, through the lifting, stretching and arching of the soft palate by muscular control.

In spite of certain errors, Malaigne, in 1831, made valuable contributions to vocal science by assigning to the ventricles the function of securing freedom to the glottis lips by their curvature upward, like the lips of a horn-player, during phonation. He also described the variations in form occuring in tongue and soft palate in the production of high sounds.

In the year following, Bennati published a theory of vocal mechanism which in part reproduced an idea uttered somewhat earlier by Delau, namely, limiting laryngeal agency to the making of low tones, except possibly in a secondary sense, and attributing the higher tones to the muscles of the tongue, hyoid bone, and soft palate. While

his observations on the action of tongue and soft palate are exact, these organs had not wholly escaped the notice of such earlier physiologists as Haller, and the simplest experiments utterly disprove Delau's view of the complete inaction of the larynx for the production of any tone, be this high or low.

A. von Haller (1708-1777).

Lehfeldt, in 1835, was first to maintain that in falsetto voice only the free edges of the vocal folds vibrate, although affected throughout their length in chest production, a theory adopted by J. Mueller and other investigators. He also held that, with all parts of the vocal apparatus keeping an unchanged position, the sound in falsetto is higher than in chest production. Battaille, however, by means of the laryngoscope proved that the glottis immediately changes shape when passing from chest to falsetto production, without interruption of sound.

In 1875 Tyndall, following Helmholtz, states that "the vocal organ in man is a reed-instrument, the vibrating reed being elastic bands placed at the top of the trachea, and capable of various degrees of tension."

In a word, from the days of Hippocrates to the present, the mechanism of voice has been likened to that of reed, stringed instrument, horn, pipe, and even to a combination of reed, horn, and strings; yet no one has solved the problem of half-steps to which the voice is capable of adjusting itself, or indeed of anything except harmonics. When doctors differ thus among themselves, how shall the laity decide?

Dr. John McAllister, Bellevue Hospital, N. Y. C.

Through the noted surgical anatomist, Dr. McAllister, I have been able to obtain material almost living, from which the equally noted instrument-maker, Edmund Otto, has constructed for me a manikin reproducing the human throat in its natural form and consistency, meanwhile permitting certain psychological laws to be brought into play. By an adjustment of uvula and soft palate, half-steps were readily produced, which result leads me to conclude—and I believe I am the first to state it—that the human vocal organ is best compared to a cornet, in that the action of the lips, or cords, is absolutely pyramidal.

Edmund Otto.

In examining the vocal folds one seems to see the lip of the player applied to the mouthpiece of the cornet. The muscles of the vocal folds are capable of innumerable positions, as are the fibres of the oral sphincter, or muscle of the lips, running circularly, vertically, and horizontally, in small bundles or fasciculi to upper and lower lips, drawing them up or down and compelling circular contraction as well as raising their corners or depressing them. The muscles leading to the apertures of the nose, eyes and ears are web-like attachments that weave a beautiful correlation and coördination, as well as automatic action, with every one of our special senses. The vocal folds being the player's lips, the ventricular bands form the base of the cup into which they pour their song.

While considering the statement that the instrument of voice resembles the cornet, let us go into it a little more in detail for correct comparison.

The aperture of the mouth is like the cornet.

The action of the lips against the aperture of the cornet very strikingly calls attention to the action of the lips and the eventuation of the final components of song, namely, enunciation, and diction. For sound alone in the cornet, one uses the lips exactly the same as the vocal cords are used in singing.

Upper lip is the factor in cornet playing. As one applies the lips to the cornet, one practically employs the same movements as in the vocal effort.

Mechanical reproduction of semitones.

By unwinding a cornet's curves and adding its valve-scope, a tube of fourteen feet is the result. Manipulation of the valves and adjustments of the mouth can shorten the sound-waves in this tube so as to obtain a range of four and one-half octaves. In the shaft of a cornet there are three or four small cylinders, controlled by valves that can alter tones by half-steps. In like manner, with tongue, soft palate and uvula for valves, stirred to action by the epiglottis just above the vocal folds, the singer can alter tonal pitch by semitones. Progressing further, the soft palate, dividing the sound-waves as they leave the throat, is capable of producing tones at intervals of half-steps; the tongue also works in conjunction with this. In a

reproduction of the human mechanism by the construction of three oval spaces thus: From nose to soft palate; from mouth to base of tongue; soft palate to pharyngeal wall; and from base of tongue and epiglottis to the vocal folds themselves, valvular action can produce many half-steps, thereby developing the old idea of a horn, or bugle, for the vocal instrument into that of a cornet.

This scheme is deduced from a model of the human vocal apparatus, with unimportant parts eliminated. The upper hollow space represents the actual form of the skull with the septum and turbinates removed as far as the hard palate which forms the base of the cavity. The second chamber is roofed by the hard palate and supported by the hyoid bone. The third, including the epiglottis and full laryngeal apparatus, ends where the arytenoids are contacted at the fifth cervical vertebra with the spine. Special attention is invited to this position of the arytenoids and to the constructive work of the hyoid and hard palate, for the purpose of resonance.

Six organs included in vocal instrument

These analogies, however, apply to the vocal instrument only as a laryngeal and supra-laryngeal structure. When we include the whole body we find that it belongs to the breathing system, and is operated automatically by five units, acting simultaneously, though each is subject to a law of intake and outgo. Its mechanism contains six organs: Abdomen, to furnish dynamic power for compression of lungs; lungs, to furnish and compress air for momentum; larynx, to generate sound; mouth, for articulation, overtone and resonance; pharyngeal dome, for reverberation and overtone; and nose, for resonance and overtone. In the nose and dome the breaking up and the subdivision of cyclones takes place, and the subsequent and safe conduction of the sympathetic and final vibrations is performed in a manner tending to preserve the last singing vibrations in the sinuses with a further conduction by sympathy into the finality of disappearance.

This system is controlled by the jaw, which is the first unit in vocal procedure. It is expressed by the mouth, which reflects and regulates every eventuated

sense of motion of all other parts of the body concerned in speech and song.

All the vocal valves of which the mouth is the ultimate and visible representative, are composed of eight parts, and, being sphincteric, they are controlled by muscular action which either opens or closes the tube. They are five in number: (The anus) the dynamic control; (the diaphragm) the pneumatic control; (the glottis) the momentic control; (the palate, tongue and epiglottis) the sonoric control; (the mouth) the vocalic control. Seven organs are under their domination: Abdomen, thorax, larynx, pharynx, dome, nose and mouth. The kinetic unit, or sense of motion, in these controls is the first law of vocal procedure, the jaw regulating the vocalic sphincter for the utterance of language, either spoken or sung.

Having arrived at so much understanding of this vocal instrument from a study of procedure and effects, in the light of anatomico-physiological observation, let us go back to first principles for a closer knowledge of its inception, development, and possibilities.

First principles applied to the vocal instrument.

Imagine one's self an observer, stationed at the centre of the universe at creation's dawn; then would one see a ray of sunlight, the source of all light, motion, and energy, strike the earth. The angle of the ray determines the energy it can impart and the amount of life and motion it will sustain. The light has also within itself a motion, due to the movement of its particles, according to the law of pyramids. What more natural than that this pyramidal principle, the very beginning of things, should occur in all phases of creation, even voice-manifestation?

The pyramid.

The triangle.

Following this up, we find that a general cross-section of the simplest pyramid is a triangle; the two triangles of suitable shape together form a square.

Square and cube.

Another form in which nature works is the circle. Regarded as a zero it bespeaks negation, the condition of the earth till animated by the light. A dot or point is the least division of space. The dot prolonged gives the line, in one form, in another the arc or circumference, which is the only measure of the angle that exists. Extended indefinitely beyond human comprehension, the circle typifies

infinity. Given solidity, the circle becomes the sphere. Similarly, in its least form the drop is the smallest physical division of liquids. Expanded, it represents the earth, moon, sun, or the universe.

From nature's own forms, then, pyramid and sphere with their derivatives, the triangles, cubes, circles, and all the rest, we must work to understand our subject in its geometrical aspect.

We must also consider the movements of the parts among themselves, as in the pyramidal ray of sunlight, according to the laws of kinetics. *Kineo* is Greek for "I move"; kinetic motion describes changes in position; kinetic evolution describes everything in motion through impulse of its individual or pyramidal energy.

Pyramidal forms.

Vocal kinetics must account for relative changes in the position of the parts of the machine made up of solids, liquids, gases, and possibly finer substances, materials either rigid or more or less elastic, so controlled as to utilize energy with the highest possible efficiency in tone-production.

Science of numbers.

The geometric and kinetic aspects, with their involution of the science of numbers and its mysteries, though too little regarded to-day, were diligently investigated by such wise men as Pythagoras and Euclid.

Thus far it is plainly evident that all the mysteries of the universe can be interpreted by the forty-seventh problem of Euclid, with a triangle the sides of which are in the relation of 3, 4, and 5, or the measurements of the human jaw. These numbers, which, in their several relations and combinations, enter into vocal science, govern the cord-forms and the correspondences in the laws of color as well as those of voice.

In the light of first principles we shall find that voice-mechanism is subject to the laws of these three fundamentals that we have briefly outlined—geometry, kinemetria, and number-relations. Geometrically, it begins with matter-forms at rest; circles, cubes, and the like. Then evolution develops it on the lines of pyramidal formations, according to the laws of kinetic motion, the developer of energy. And finally, these pyramido-prismal parts

are all related in ordinates of three planes, proportioned as three, four, and five, and are subject to inherent forces.

Twelve the governmental number of creation.

Three, four, and five. The sum of these numbers is twelve, the governmental number of creation, the emblem of the Holy City with its twelve gates and twenty-four elders sitting about the throne. It will likewise prove the key to our understanding of the vocal instrument and unlock the voice of the divine within us.

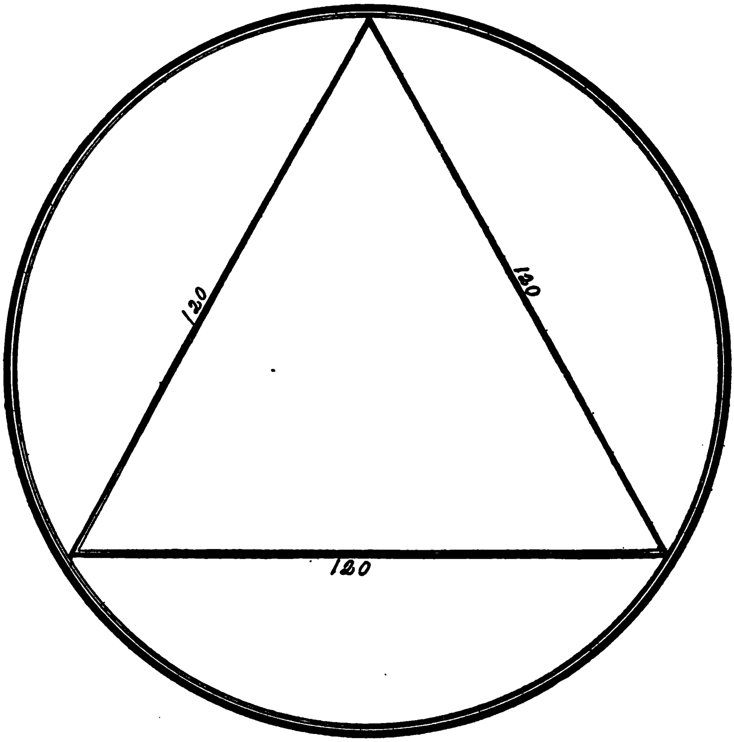


Fig. 20. Equilateral Triangle.

William F. Fraetas

Geometrically considered, the vocal mechanism begins with the circle, symbolizing generation and renascence, with their endless completeness, processes and eternities.

The circle, with its central dot, divided into 360 degrees, is the foundation for a study of the essential unity

and infinite variety of phenomena in vocal architecture. Not only is it considered the foundation, but it is also regarded as the guiding compass for measuring the scale of the voice.

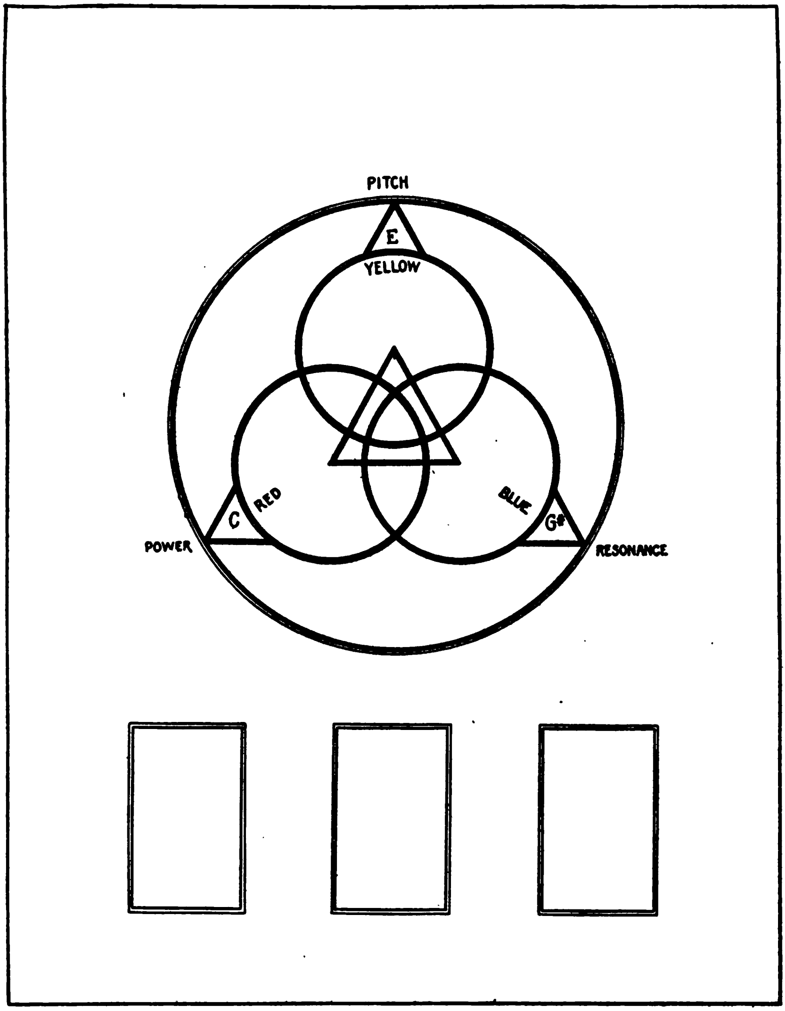


Fig. 21. Zones for Primary Colors.

Inscribing an equilateral triangle in the circle, each point of contact becomes a unit of force, a centre for tone and color.

About these we draw three new circles, zones for the primary color forces as found everywhere in nature; namely, red = heat; yellow = light; and blue = electricity. Later we shall show that voice is a dynamo, producing air-currents that correspond to the vibrations of musical tones and the undulations of color and light.

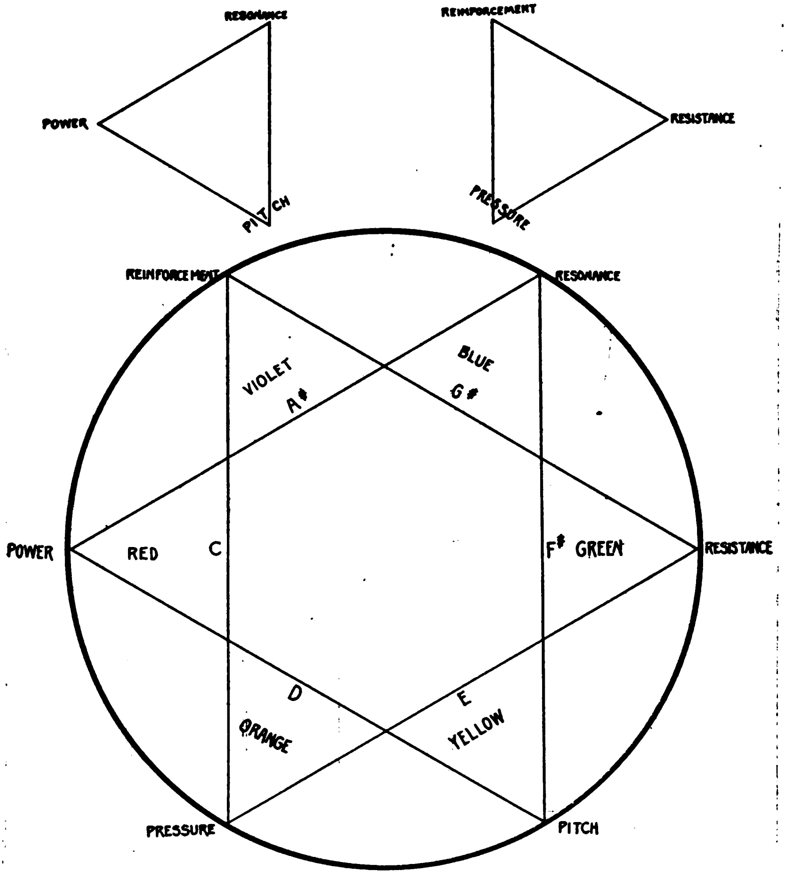


Fig. 22. Spheres of Complementary Color,

These zones or spheres which represent the outer aspects of voice correspond to as many inward or psychological states, roughly classed thus: Red, power, passionate, dominating and exciting; yellow, the momentic,

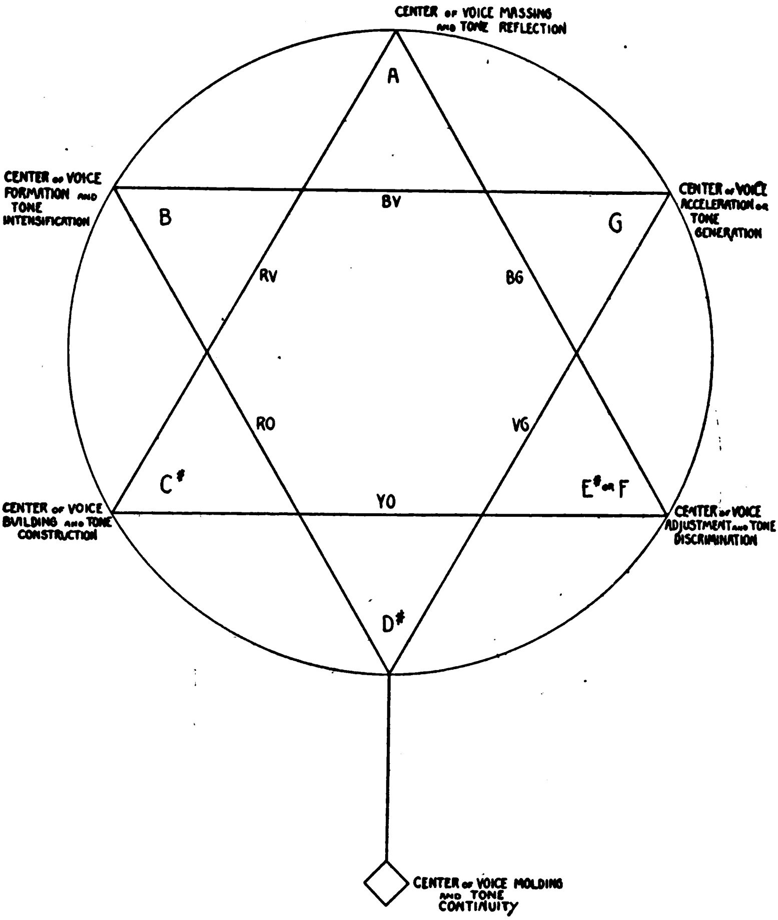


Fig. 23. Hexalpha: Sex-Dynamic.

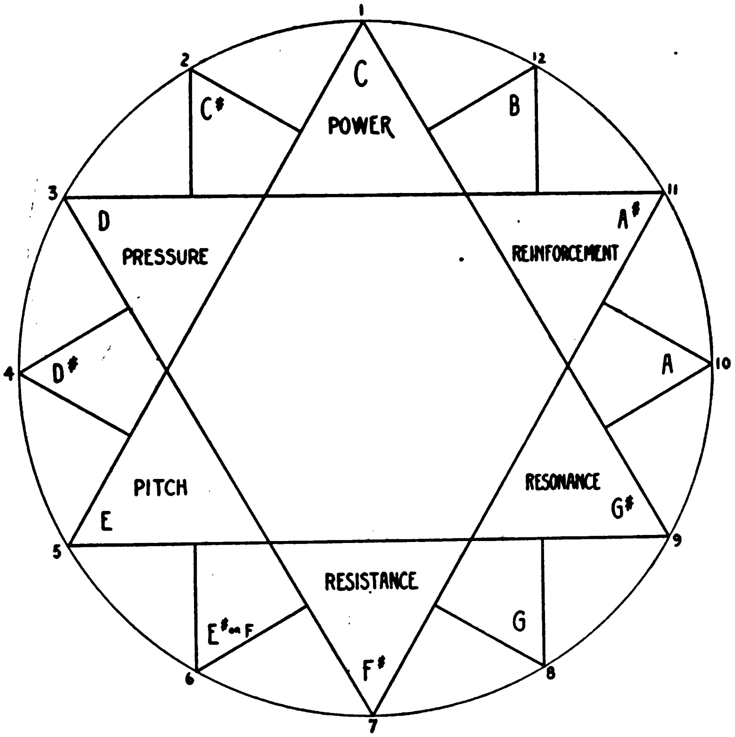


Fig. 24. The Star Potential.

sentimental, spiritual and sympathetic; blue, the resonantic, thoughtful, meditative, contemplative. As interior spheres they have a direct and important bearing upon pure tone and vocal beauty, determining the very moods of the soul as these are reflected at the vocal folds. Red is pitched at C; yellow at E; and blue at G.

With these zones in operation, the triangle of tone begins to act, and our circle-compass develops new figures. We shall show later that this actually happens and is proved by physical experiment, namely, with sand-shapes created on stretched membranes by vibrations of voice or other instrument.

The second triangle is developed by the action of the vocal apparatus, and the stress of vibratory force due to the inertia of the points of force, that is to say, the stationary relationship of power, resonance, and pitch; or the red, blue, and yellow of the voice. It stands in inverted relation to its predecessor, and presents the secondary aspect of tone and color; orange pitched at D; green at F; and violet at A—the exact tone and color complements of the former scheme.

This hexalpha formed by the two triangles; this six-pointed star is the Sex-Dynamic-Centre of the human voice, the Energy star, and upon the understanding of its power the whole life and structure of vocal mechanism rests.

Let us not forget, however, the twelve pillars of our temple, the number that governs all creative effort. Where shall we find the other correspondence to add to our Energia? Where indeed but by harking back to Genesis, and fulfilling the destiny of man by woman.

Another hexalpha, accordingly, must be developed with tones and colors—the Star of Potential.

This results naturally from anastomosis, through the interaction of the six points of our first star; power (C) red; pressure (D) orange; pitch (E) yellow; resistance (F) green; resonance (G) blue; and reinforcement (A) violet.

Two stars of six colors, points, and tones. Energy, the masculine, and Potential, the feminine. Combined, they present the twelve points of the vocal compass, the

perfect union typified by the circle. Voice at once creator and creative, and colors blended into radiant light.

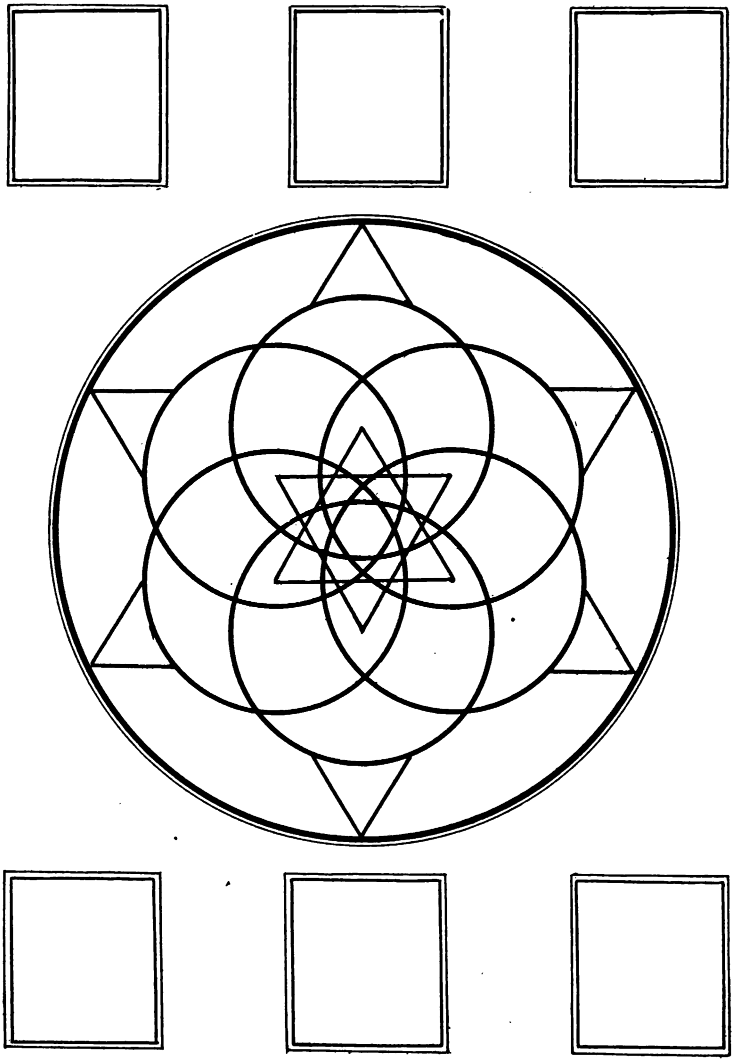


Fig. 25. Radiant Light.

Vocal kinetics.

Studying the vocal instrument from its kinetic aspect, in other words, from a sense of motion in voice, we revert to our pyramido-prismo-helico-conico-spherical relationship

and find its correspondences in the human structure. Voice then appears as force, the action of the kinetic energy on prisms and pyramids solid, flexible, and hollow spaces in the human frame.[1]

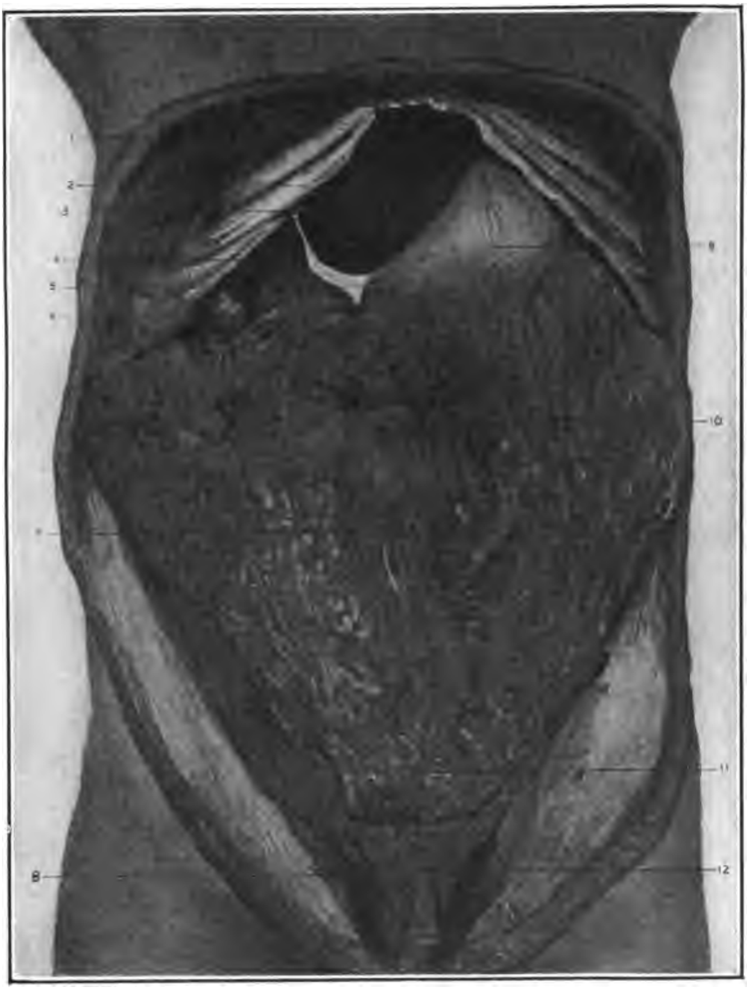


Fig. 26. Dynamic Pyramid.

[1] In general the similarity to geometrical forms is expressed by likening the parts to pyramids; the pyramids and prisms are closely related, mathematically, as the prism may be considered a pyramid whose apex is at infinity, and whose lateral edges, therefore, become parallel. The dihedral

Dynamic pyramid.

The first is the Dynamic pyramid (see Fig. 27), the source of energy. Its base is formed by the lower side of the diaphragm with its sides enveloped in the great omentum, the fatty tissue covering the intestines, the apex of the pyramid pointing downward to the anus or posterior cell. A semi-solid bag, its pressures are held in control by the anus with the great omentum and diaphragm. Its own force moves it down and out to evacuate its contents, according to the laws of gravity and diaphragmatic compression, but in singing its action is the reverse of this. In the former its positive pole of power is at the diaphragm, but in the latter the reverse is the case, the positive pole being transferred to the posterior sphincter. The contrapuntals also exchange qualities, the umbilicus or navel receiving the negative state of the third lumbar vertebra, and vice versa.

This geometrical formation, the abdominal pyramid, is semi-solid, flexible and, though capable of many movements, both separate and conjoint, it is the main energizer and support of voice and the controller of breath in action. To the lungs above, the diaphragm offers a solid base, as it also does to the heart and roots of the lungs, while its two crura or leaves support their expanding bases. As an automatic dynamic force it equalizes all forces of compression of atmosphere or gases in the aerial lungs, with due regard to the chemistry of digestion, circulation and generation, and a thousand and one other offices. Any foreign element interfering with its ideal pyramidal action, no matter how insignificant at first this may appear, will sooner or later be recognized by its conscience, the nervous system.

The Pneumatic pyramid finds its base at the upper side of the diaphragm, its apex at the apex of the lungs, while its sides are formed by the thoracic cage. Furthermore, every included organ is a pyramid. The heart, gigantic and powerful, working incessantly; the lungs, with the right having a third lobe to supply the loss

angles between the faces of prisms and pyramids are identical and may be called the prismal angle. The action of light on the faces of pyramid and prism is identical.

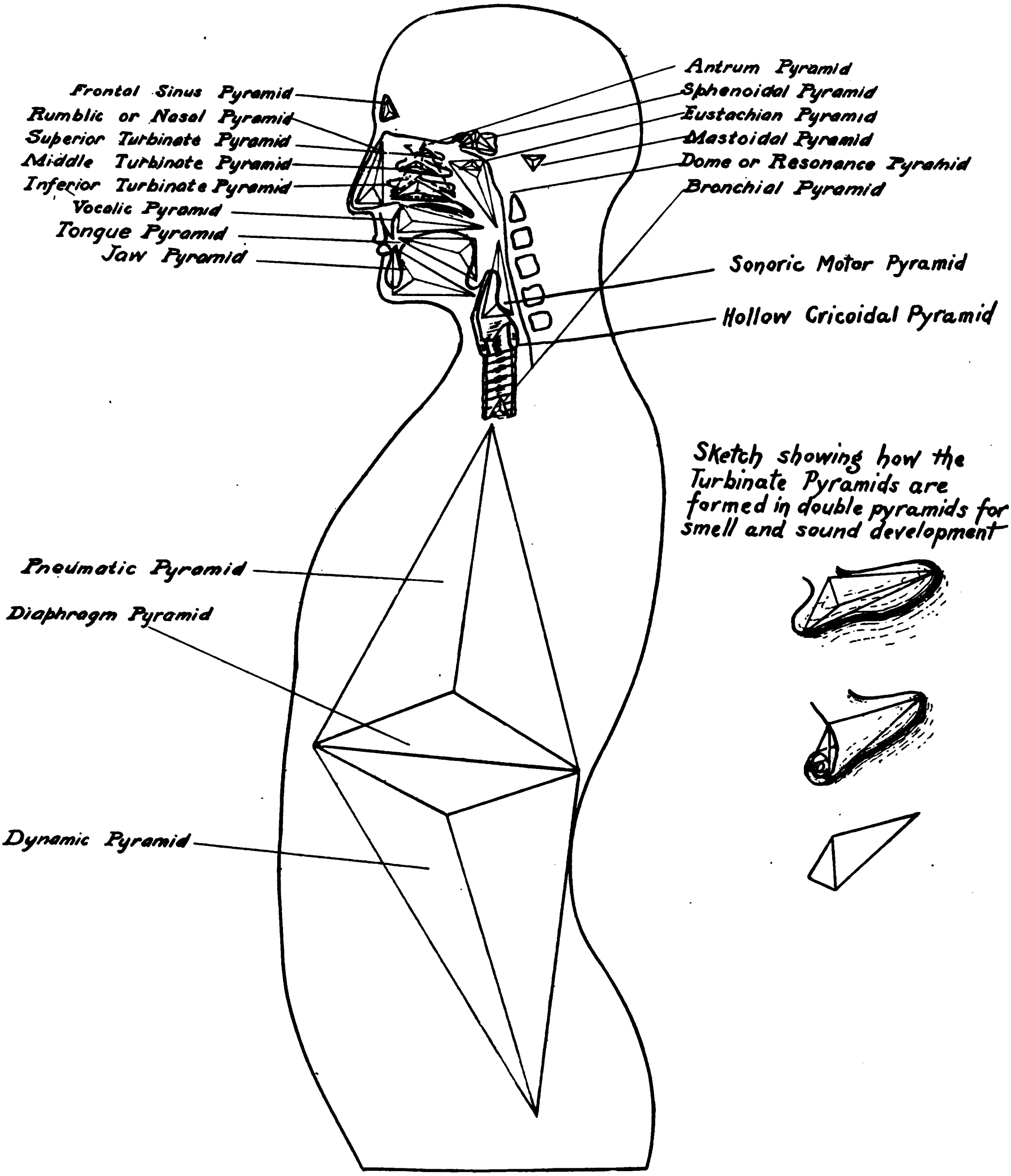


Fig. 27. Pyramidal Voice-Chart.

of tissue in its fellow occasioned by the presence of the heart as well as to balance the pressure of this on the left side, are both pyramidal in form. Here, also, it is to be noted that the measurements are as three, four and five.

Thirdly comes the Air-moulding pyramidal cricoid cartilage. Around each tracheal ring is a pyramidal ruga till we come to the cricoid with its circular orifice through which the air, having been brought up to a focus, passes to the vocal folds. These, on their underside, now form the motor point, converting pneumatic power into momentic strokes or units of sound. Meanwhile the upper surfaces, while resisting the pressure from below, receive reverberations from the resonators above, making this pyramid the initial controller of resonance. To this formation belongs pitch, also conditioned at the glottic lips by their length, mass and tension.

The vocal folds attached to the thyroid angle by their apices, with bases set in the arytenoids, are also pyramidal; no less pyramidal in form are the arytenoid cartilages, as are likewise the cornicula Santorini, set as they are on their solid and bony bases. These are the pyramids of indication, because the physician or trained observer can see them, and from their location decide whether anything is amiss in the intrinsic action of the folds. A pyramidal shell is the enclosing thyroid.

The vocal folds are shaped as three planes, meeting in an apex at the Adam's apple. Does this not give the analogous kinetic position by which the Revelation of the Rainbow in the phenomenon of light is possible? False vocal bands make the upper resonance plane possible as regulators and balancers of true cordal actions in overtone formation. The meeting of three planes in an apex makes the thyroid angle not only possible but absolutely necessary to the accomplishment of the kinetic scale of sound by the angle there formed.

Through their side of attachment the vocal folds communicate their burden of power, namely resonance and pitch, to the whole body, causing sympathetic vibrations to thrill it; and conversely, if disease lurks anywhere it will logically show its effect on tone.

So far our pyramids have been semi-solid, though flexible, forming three semi-solid, and three hard, but adjustable, spaces. To the first belong the pyramidal forms of the dynamic, the pneumatic, and the air-moulding units; to the second, those of the arytenoids, cartilages of Santorini, and the vocal folds. We now have six mechanical units, each arranged with a solid force and two developing forces.

First: The Momentic Unit, the space between the vocal folds and ventricles of the larynx, like the cup of the cornet against which the player's lips move, regulating tone and influencing resonance. (See Fig. 11.)

Second: The Sonoric Unit, formed by the space bounded by vocal folds, epiglottis, and posterior pharyngeal wall. Simple sound is formed here without color or individuality.

Third: The Tonsillar Space, the first and auxillary resonator, the vestibule of the vocalic and resonantic units, just as the ventricular space formed the vestibule to the sonoric unit.

Fourth: The Lower Resonantic, between epiglottis, tongue, soft palate, pharyngeal dome, and choanæ.

Fifth: The Vocalic, formed and controlled by palate, tongue, cheeks, and lips.

Sixth: The Upper Resonantic, the nasal cavities with their septal turbinated bony divisions; also sinuses to conduct sympathetic vibrations to the surrounding and adjacent hollow bony pyramidal sinuses, which act as shock-absorbers.

Color analogies. Prismatic and pyramidal governments, to the number of twelve, make the study of pyramidal analogy between sound and light necessary. In the production of the momentum of sound, double pyramidal forces are at work, and, through the arytenoids and vocal folds, offer an anchorage which control tension, and with the aid of outside muscles, condition power, quality and pitch. **The spectrum.** Turn an ordinary crystal prism to the light, and white light ensues. When turned another way, the beam is dispersed into the spectrum. When again turned a third way toward the light, darkness supervenes.

Let us consider the dispersed beam, comparing its several rays to the tone produced by the human instrument. Red is hardest to refract, because of the length of its wave. Direct tones come through the mouth and vibrate best at C—and the mouth is red. This is the longest unobstructed passage from vocal folds to lips.

Red rays correspond to mouth emissions.

Taking basic C of any voice, the most readily intonated sound or unit, we find its detonations come most freely from the mouth because this offers the more direct and least obstructed passage, while its higher components have to find egress through the nasal complex. What more obvious than that the long waves will seek the easier way? The shorter waves, divided by the choanae, and subdivided by the solid pyramids of the turbinates, are projected by the forces of porosity and elasticity from the accessory sinuses that respond to the most delicate and vanishing vibrations, imparting to them the smooth-flowing, lyric quality.

Violet rays, to nasal, due to relative wave-lengths.

In the light-spectrum the red rays, due to the longer waves, are harder to refract than the short-waved violet. Red, then, corresponds with our mouth-emitted sounds—and the mouth itself is red. Now can it be mere chance that the nasal chamber, home of the short-waved tones, from its abundant venous supply is whitish lavender, the highest frequency of the solar spectrum? Our vowel-tone is a triad. It is formed in the sonoric and nasal resonators, likewise the oral sphincter. With the latter representing the red end of the spectrum and the nasal the blue, we should expect our fundamental to be produced by a source corresponding to the middle color; and so it is, the vocal bands being of a whitish yellow. Breath unacted on by momentum comes soundlessly through the glottic valve (the rima), which is shaped in a state of rest like a pyramid, and corresponds to the crystal turned toward the light, when only darkness supervenes. Breath converted into momentum, but undifferentiated into tone-components, corresponds to white light, which contains all colors.

A vocal tone a pyramidal formed triad, the components of which correspond to the three primary colors.

Newton, one of the greatest of physicists, found a connection between the relative spaces occupied by each color, and the relative vibrations of the notes of the scale;

Isaac Newton (1642-1727).

Relative wave-lengths only true basis of comparison.

the only satisfactory basis of comparison, however, is in the ratio of their wave-lengths respectively, particularly as they are found within the limits that comprise the range of our organic sensibilities through eye and ear.

Eye and ear compared.

The eye-prism, at once the smallest and finest organ of the human mechanism, can take in only an octave and a half of color, measured by vibrating frequencies; whereas, the average ear detects over six octaves which, in the case of acute aural sensibility, may extend to seven. Minute differences also, not perceptible to the eye, can be detected by the ear. — A table of relative wave-lengths of sound color presents the following results:

Color	Ratio	Note	Ratio
Red	100	C	100
Orange	89	D	89
Yellow	81	E	81
Green	75	F	75
Blue . . . 69, Indigo . . 64 } mean	67	G	67
Violet	60	A	60
Ultra-violet	53	B	53
Obscure	50	C	50

The final analogy the governmental.

By dividing the spectrum into twelve and placing these in as many segments of a circle, with the twelve half-steps of which a musical scale is formed in their natural correspondences, then with a key-triangle as indicator, we shall find that any three colors pointed out at the same time by the vertices are always harmonious, while in the musical scale the three notes indicated will form the chord of either the major or the minor, according to which side is used. Twelve, and only twelve, possible combinations for the major, and as many minor. Have we not now our final governmental scheme, the rainbow of light and the scale of sound, the harmony which is the soul of music, brought about by the pyramido-prismatic forces that form the Vocal Instrument, the twenty-four Elders that sit about the Throne of Light, and its twin manifestation, Voice?

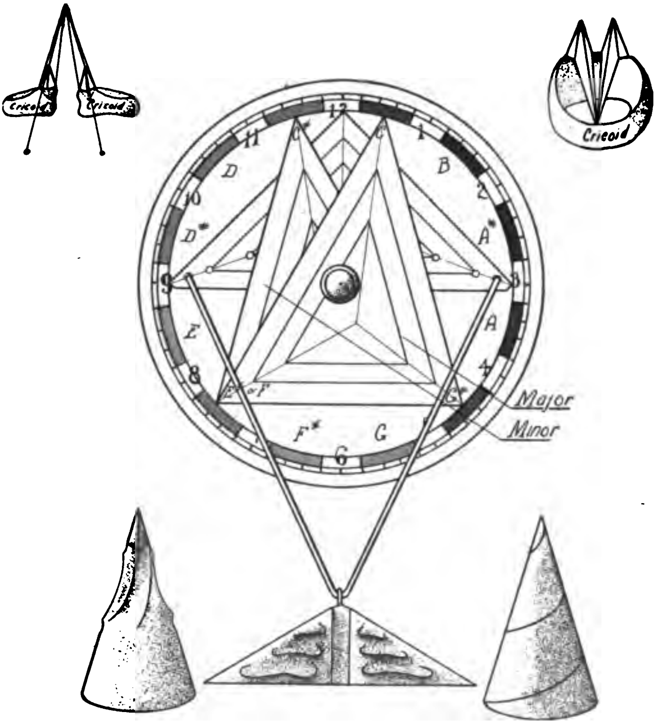


Fig. 28. The Kinetor.

CHAPTER VII

The Vocal Act

Voice is a habit; the singing voice is a blend of brain and body in a perfect balance of power, resonance and pitch.

The Vocal Act depends on an understanding of the Vocal Instrument, with an application of the principles on which this has been evolved, to the end of tone-production, as achieved by vocal procedure.

The vocal instrument, as we have seen, comprises the whole being, brain, body, and soul, energized automatically for the creative effort of sound-generation according to laws based on fundamental principles.

Aero-vibrations, analogous to those of light, are the momentic source of voice.

The vibrating source of voice is in the larynx, and is formed by that pair of ligamentous pyramidal muscular lips erroneously called cords. Air in the ordinary process of breathing is suffered to pass between these jealous warders of the glottis unopposed, but air expelled with voice-intention from infra-laryngeal units, activates them into opposition, with a swing of their hinge-attachment that draws them together through two-thirds of their extent. The impact of the persistent breath sets them vibrating along their free edges and throughout their mass. Lest this impact should prove too violent a shock, the elastic walls of trachea, larynx and crico-thyroid membrane assist in regulating the blast from below.

Until recently the cord-stretching of a stringed instrument was used as an example for the action of the vocal folds; but Garcia, of laryngoscope fame, who was an independent investigator as well as teacher, advanced a theory which later authorities, like Marage, have supported by experimental proof, and to which others of note, including John Howard and Charles Lunn, also subscribed. Answering the question, What produces voice? Garcia replies, "The two lips of the glottis, which are open during

Garcia. **Marage.** **Howard.** **Lunn.**

breathing, but meet when there is preparation to produce sound, closing the passage with a degree of energy proportioned to the nature of the sound and the power with which this is to be emitted. Pushed upward by the air, they give way, but immediately return to their contact, and recommence their act of adjustment. The intermittent explosions thus formed, when regular and rapid enough, produce sound." And, illustrating this view, he compares the action of the glottic lips to that of the lips of a horn-player. My own theory of the cornet-player I have already described.

While this theory of puffs and detonations has been accepted widely—almost universally—yet the greatest scientists agree that their work of research on these lines is still in its incipiency. We admit that the vocal folds themselves vibrate, besides dividing the air-column into explosions. But another highly important character of these vibrations is that they are spiral in shape for any given tone; and this has been determined with a scientific accuracy that may be regarded as ultimate. All this enables us to formulate an orderly procedure by which teacher and pupil may obtain the best results in song. Fig. 29.

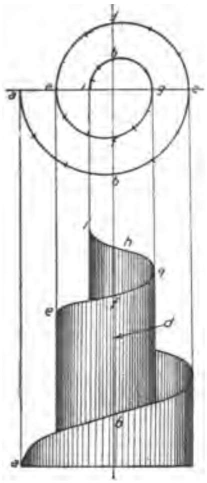


Fig. 29. Spiral.

The vocal cords constitute the motor function of the vocalion. As the momentic autonomy, they govern all movements and momentum; and as this momentum is, in turn, the call to action for the resonantic or sympathetic functions above, it is readily seen that the movements of the vocal cords must be far more intricate and complex than allowed for by any theory heretofore advanced, but now reasoned out and demonstrated in Vocal Art-Science by the laws of kinesiology. In the course of analyzing these complexities and intricacies, and their results, I have failed to find in writings on vocal cords, or phonetics generally, any evidence of knowledge of the following facts:

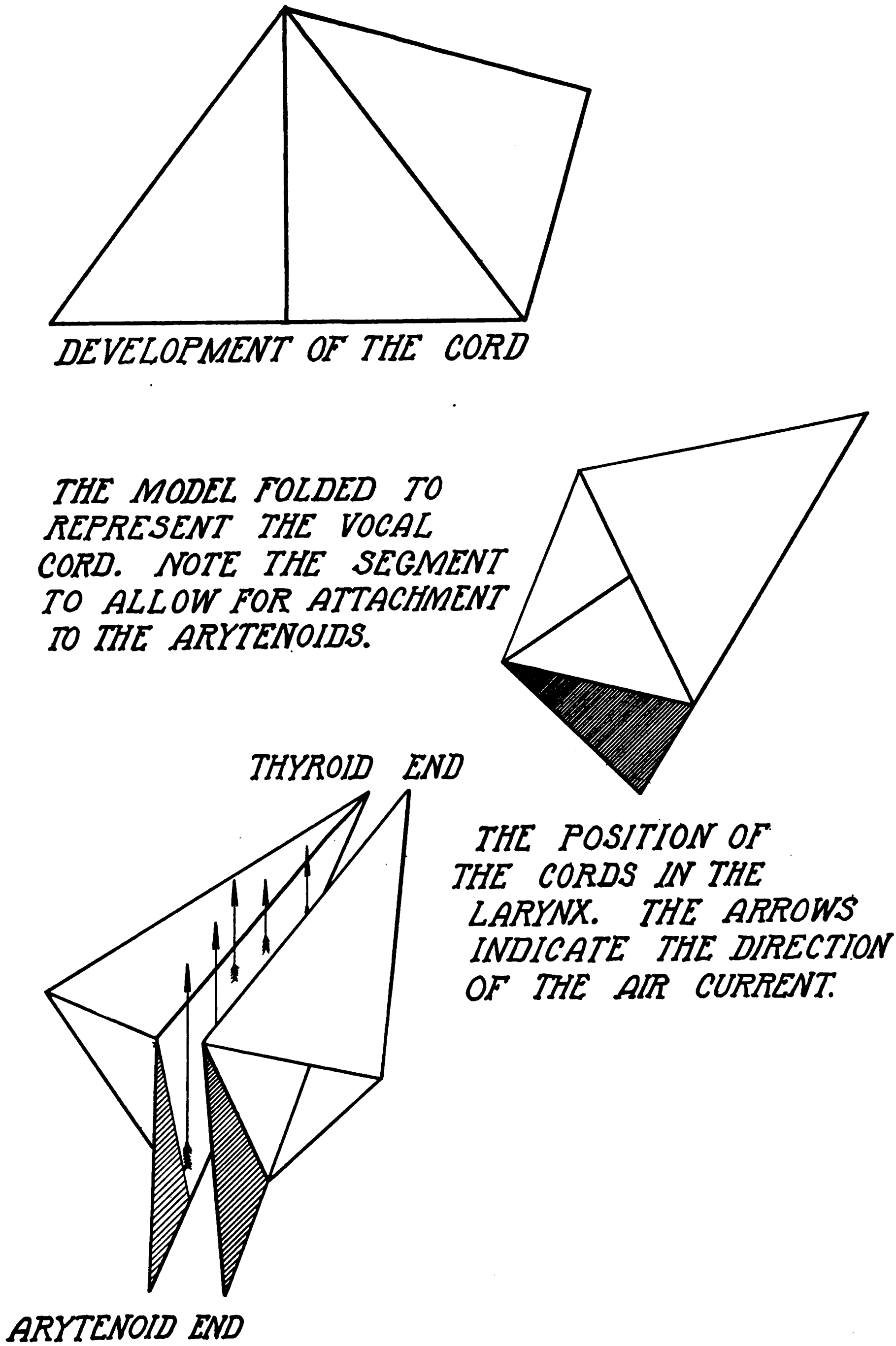


Fig. 30. Pyramidal Vocal Cords.
(Karl Kraft)

The vocal cords arise from the thyroid end of the thyroid cartilage at an absolute point and spread in three planes to the arytenoids.

Taking these three planes and placing them on each other, we find them all equal. But, on adjusting them for tone-production, we find that the dark plane (the side of the pyramid without light), the one which is attached to the muscles and tissues of the thyroid, will have to be longer by one-sixth of its space from the linear measurements to fulfill its obligation of equalization of force of the other planes. As we turn back this blank plane above, it perfectly fulfills the demand of the dimensions of the true vocal cord of its control. The under plane is the power plane; the upper plane is the resonance plane; the third plane, which is attached to the thyroid, is the muscular or motor plane. These three planes meet the three planes of arytenoids at a certain angle. Their planes coalesce and end in an apex at the point of the cartilage of Santorini.

If, in our observation, we project the planes of the vocal cords from where they coalesce with the three planes of the arytenoids back again toward the thyroid, they will be found to meet in an apex also at a point on that cartilage. This is also true of the false vocal cords.

This can be observed more readily with two of the planes than with the third, for this is a blank plane, being attached to the muscles and tissues of the thyroid cartilage; on extension in the same direction as the other two planes it will be found to meet in a like apex at a definite point of the thyroid.

Hitherto the action of the vocal cords has been studied only from the laws of forces of one plane. What I have said above, however, proves that vocal-cord action is subject to the geometric laws of forces moving in three planes—the pyramid—and must be studied, explained and demonstrated in order to formulate a true system of Vocal Art-Science. One might also find metaphysical relationship in the law of the three planes of the vocal cords and the triple alliance between psychology, physiology and emotionalism—mind, body and soul—in voice-production.

It is easy to deduce the function of the ventricles between the true and false cords by the author's newly-discovered law of the pyramid as applied to the action of the vocal folds along three planes. Before proceeding further it will be well to define a term hereafter to be used, namely, "Rule of Thumb"; an analogy used for the first time in history.

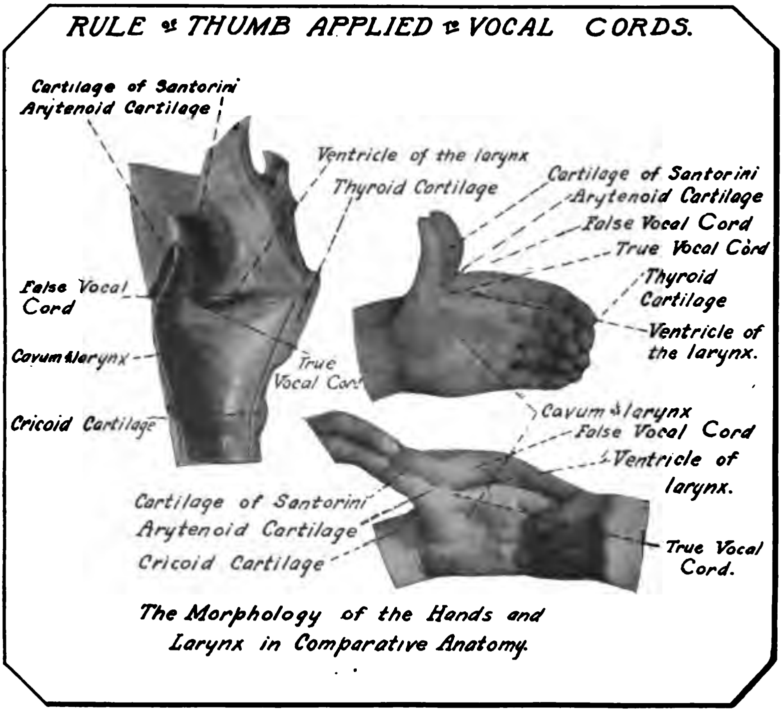


Fig. 31.

The true and false vocal folds as well as the several cartilages of the larynx may be graphically demonstrated and in proper relation, one to the other, in the following manner:

Place the hand of another person outside and around your own in exact conformation, so that the thumbs and forefingers are aligned and in opposition. We shall then find that the first and second joint or phalanx of the thumb

represents the cartilage of Santorini; the third phalanx or metacarpal corresponds to the arytenoid bone; and the mass composed of the carpal bones occupies the position of the cricoid.

The web between thumb and forefinger is the pyramid of the vocal cords; the web of the superimposed hand, the false vocal cords; while the metacarpal phalanges of the finger conform to the position of the thyroid.

It is a misnomer, this term "false vocal cords," for the structure is a pyramidal assisting companion and, as such, should never be termed "false," for it is an absolutely necessary directing pyramid. The first member, the arytenoid, is also just as necessary to definite and correct action as is the cord itself, and probably the latter with its associated fibres running above and into the apex end of the cartilage of Santorini, and to the pharynx behind, gives another force, namely, the consummation of direction of the vibrations (set in motion through the cordal forces) which, deflected by the vocal pyramids and prisms, result in a veritable helix of two and one-half turns; which explains clearly the conico-helicoidal relationship of voice.

The laws which have just been discussed, have a decided influence on voice-mechanism and present an entirely new basis for voice-production and scientific study.

The vocal act, on the singer's part, consists in a series of adjustments of automatic forces which eventuates toward a standard or ideal tone. The mechanism of this consists in putting the whole body into sympathetic understanding of what is required, like that of a trained soldier answering the command, "Attention!" At such command the vocal units must operate in sequence, the extrinsic so assembled for vocal action that the intrinsic may have free play in automatic and unified action.

Breath, natural and automatic, must be subjected to pressure in order to arouse glottic coöperative opposition, and the larynx must be consciously left without interference from muscle-control in order that this procedure may produce voice; furthermore, the supra-laryngeal units must adjust themselves to resonance. Confined to the

larynx, the vocal act may be described as fixation, approximation, fold-stretching, and attack. Fixation, as we have already seen, means procedures by which the larynx is placed in the right relation to the whole body.

Pitch, or voice-placing in the scale, occurs as a mental concept simultaneously with voice-intention. The singer seeks to produce a tone having a relative position in the scale, aligning this by comparison with a tone sounded on some instrument, or from experience gained by habits of accuracy, and accordingly materializes the breath into the reproduction of a tone conjured up by the brain and audited by the true authority, the inner ear, as distinguished from the outer ear that hears like the ear of an audience.

Pitch, physically referred to as length of sound-wave, or frequency of vibration, is the generating source, and is, in the vox humana, conditioned by the length, weight, shape, and tension of the fleshy mass forming the pyramidal vocal folds. Voluntary control transfers to the automatic pyramidal regulators the special adjustments needed to measure up the pitch of the tone produced to that of the tone conceived.

Power or intensity in a musical tone, physically referred to, is the maximum height of a wave, and depends in part on the extent of the swing of the glottal gates, the reinforcement offered by the resonating systems, and the character of the curves instilled by its helix of two and one-half turns. The former is brought about by increase of air-pressure and proportionate outlay of energy, yet it can amplify the wave only from twenty-five to thirtyfold, while resonance, an inherent faculty, has in it the gift to raise wave-height some hundredfold. Resonance, therefore, is the important factor in power or intensity, the second characteristic of a musical tone.

The third characteristic quality is contributed in its entirety by resonance. The helix of two and one-half turns gives to power and resonance the momentic fundamental direction.

The pitch of a tone, as vocal physics teaches us, is that of its fundamental, with a harmonic relationship

existing between it and the overtone present. That these overtones are found in the human voice is due to the phenomenon of segmentation in the vocal folds, according to the law of sectional vibration, when the generating force is damped in computable sequences, and sympathetically connected by muscles to the harmonious overtone resonators. The amplitude of these partials or overtones, as they leave the glottic lips, is very small; and it is to synchronous vibration that they must look for reinforcement, as well as for the quality that conditions beauty in song. Reinforcement obtained by a sounding-board, as in the case of a violin, is more than duplicated in the human vocal instrument, for while textures of the body lack the essential characteristics of dryness and homogeneity, these are more than compensated for by the mucous membranes that conduct sound. These membranes are wet, and form the wet resonators for reinforcement of tone. True, the whole bodily frame is, as we have said, a resonator, but we are now discussing special, technical reinforcements of the several components of a tone. These are formed by pharyngeal, nasal, and oral chambers. It is just here that our new discovery of a helix of two and one-half turns occurs with a fleshy cord for correlating quality. Thus incorporating a hard, bony arytenoidal pyramid for coordination of cords for reinforcement of cordal segmentation, with the object of increasing its coöperative capacity in the formation of air-vibrations of like period in the supra-laryngeal cavities.

Evidently, the vocal act demands absolute freedom for the correct swing of the laryngeal cartilages; absolute freedom for the glottic lips, that they may initiate the proper combination of fundamental and overtones; and absolute freedom for resonating influences to amplify tone while enriching it with quality. Any muscle-contraction hostile to such freedom constitutes that arch-enemy to good vocalism: *Interference.*

In procedure, the position of the body must be established. As all parts go to make up the singing-machine, their relations to the vocal act are definite. According to the kinetic principle based on the pyramid, the sides of

whose faces, expanded to the circle, are in the relation of 150°, 120°, and 90°, or five, four, and three; according to my observation, the motion necessary to produce musical voice consumes a constant fractional part of the space occupied in producing sound; in fact, a constant fractional part of all the necessary constituent compound parts is utilized in the stress, torsion and recoil of vocal kinesis.

The angle of opening of the mouth which governs the output of voice in diction and style would conform to the same principle. Thus we shall have a longitude of movement of the lower against the upper jaw of 42° to 54°, dependent on opening of jaw; this is called the kinetic scalescope voice-sector, or rainbow of its kinesis, and is the measuring scale of the balanced scales of power, quality or resonance, and pitch.

This scale is to sound what the spectrum is to light. If the action of the jaw, regulating the mouth in the emission of musical sound, is the last point of regulating voice, then what changes the position of the mouth in any way, as regards its content and capacity, causes correct voice-production or otherwise, for the reason that lips, tongue, palate, and even the cords (by the way of the thyroids), are all attached to the jaw and govern voice-form.

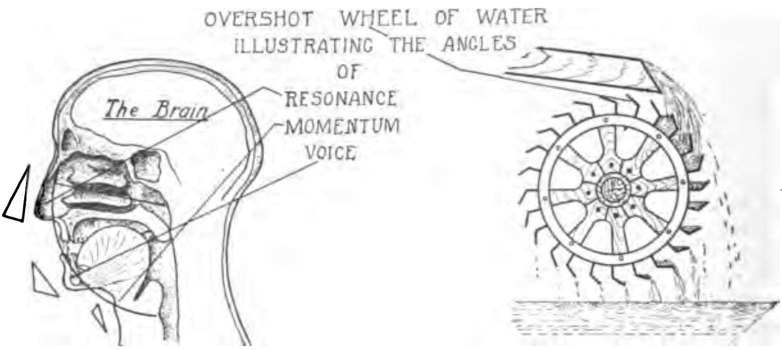


Fig. 32.

It will be noticed that when one is at rest, with the jaw closed, the vocal parts are placed at right angles. In

action the jaw should drop 12 to 15 degrees, according to the law of kinesis; for the jaw is constructed on the same principle as the overshot wheel, and is the overshot wheel of voice which forms the kinetic pyramid; in like manner one can truly say that the nose is the overshot wheel of resonance, and the Adam's apple the overshot wheel section of vocal momentum. Were the cleats slanted, the wheel would not revolve.

Nature indicates that more air-pressure should be put on the right side than the left, because of the compensating third lobe of the lung with which it balances the heart. The same may be said of the abdomen, where liver and appendix are on the right, while the left contains the large sigmoid flexure of the colon, the pancreas, stomach, and spleen, organs that are separated and not easily balanced and controlled, therefore more likely to be injured.

The crus, or leaf, of right side of the diaphragm has an excursion or movement up and down of two to three inches; hence, for support of tone, the major burden of weight is on the right foot; the left, while assuming its share, acts as a rudder to prevent swaying and to hold the body in a position favorable for the next vocal effort.

As before stated, the relation of right foot to left should be in an angle, the sides of which are as three, four, and five, or 90°, 120° and 150°—the pyramidal measurement. By raising the arm in the same relative position and at the same time dropping the jaw, the latter will through auto-suggestion assume the proper opening for the perfect "ah," or likewise the perfect tone-form for any other vowel that the emotion and the correct form of sphincterization demands.

Breathing must be normal, spontaneous, the diaphragm acting not as in governing defecation, but with the reversal of poles of power, as hereinbefore mentioned, the upper part of the chest heaving rhythmically outward both in inspiration and expiration. In inspiration this is caused by natural expansion of the lungs. In expiration, through the indrawing of the ribs by means of the intercostals and abdominal muscles, aided by the diaphragm, an upward pressure is exerted upon the lungs, with a

resultant outward movement of the chest. For this, special tests and exercises will be given.

Support of tone requires the dynamic force of the abdominal unit to be sustained in order to prevent vocal wavering and tremolo. The great central automatic sphincter, the diaphragm, must retain its hold of the abdominal contents so as to regulate the upward pressure of the semi-solid mass. Adjusted to the roots of the lungs, the unit uses the residual breath, the life-giving force, as the starting-point for the pneumatic action, and at the same time utilizes the air that is left at the bottom of the lungs from myriads of wet resonance cells, like ball-bearings, to ease heart and ribs, while rhythmic helical puffs at the glottic lips are forming tone. More air can be pumped into the lungs than they can hold because of the expiration that is always going on. This residual air, as a force, is measured by the pyramidal angle of the jaw.

The initial tone, in its output, must have a centre or point of resistance; also there must be another point for breath-control, to ensure contrapuntal action. For the tone, the point of resistance is on a direct line with the roof of the mouth, and is sensed against the gums of the upper incisors.

In addition, even on the outside of this place of tone-impingement there is united with it, as a covering, the upper lip. It is only necessary to observe at this point the coalescence of breath emitted through the nostrils and through the mouth, to discover that here is located the bridge between vocalism and resonance and the working and union of all the senses — the great psycho-physical link—the sixth sense of voice-production.

Tone must be directed forward. The law of vocal acoustics demands that a certain wet, flexible mechanism should not only develop tone, but that this should be projected, then reverberated from wall-structures, only to be again projected by resonance, the two forces combining to make pitch, which passes through the entire body by sympathetic vibrations. Vocalises follow, but without reference to the artistic production of tone, which is taken up under Vox Humana.

"Put the tone forward," all good teachers insist. "Sing toward and through the face," is another expression as frequently quoted. From our description of tone-direction you may draw your own conclusions. More particularly will this subject be dealt with in subsequent works by the author upon Polarization and Orientation.

With "Ah" for the initial individual unit, with the pyramidal angle of position taken, certain tests can corroborate the correctness of this procedure. Jaw, at the right individual angle, as described later; lips, free upon the teeth, and not restricted at the sides; tongue, flat on the floor of the mouth, its tip and margins touching the back of the lower front teeth; with the base of the tongue level and free, so that back of throat is visible from the front; palate free, so that breath passes naturally into the nose; all without conscious effort, and always under the direction of the teacher.

This position has the form of a double resonator, with two principal resonance-chambers uniting in the middle at right angles, where they are joined by a third accessory chamber, the nose. Its additional resonance is obtained by the expansion of the neck, due to the erect head, raised ribs, and larynx adjusted to "Ah."

The double nature of this resonator can be learned by introducing tuning-forks of the right pitch into the throat, until a strong reinforcement is found in that position, indicating a node at the junction of the two chambers.

The way to establish the individual or initial unit for opening of the mouth is to place a tuning-fork in front of it, pitched at either A^1 or C^2, and when the best balance of power, resonance and pitch is produced as judged by the ear, it will be found that the mouth is opened and jaw drops at exactly the correct angle for that particular singer, and that all the parts are properly adjusted, without undue relaxation, strain, or interference. This completes the personal unit of procedure for the vocal act.

The usual explanation is that the attack (*coup de glotte*, or glottic stroke) is the automatic action by which momentum is converted into sound, with all its conditions combined in one unit; but this is not correct.

The glottis is free and at vital attention, the same as the orbicularis oris, or binding lip-muscles. It is placed on the same working elements as the mouth. The rima (or rim) of the glottis corresponds with the orbicularis oris. It has an aperture the same as the mouth. A series of binding muscular filaments go up to the arytenoids from the edges of the vocal bands and epiglottis, resembling the overcasting of a buttonhole. The adjustments, in conjunction with the air upon it, correspond with the opening of the mouth in the production of "Ah," to which the teeth and folds of the orbicularis oris, at the position of vital attention for tone, give the proper aperture for the individual and initial "Ah."

We have made our analogy and described the tone "Ah" at the vocal cords. As the jaw controls with its opening and shutting the operating elements of the mouth-aperture, so the arytenoid end of the cord acts as a balancing and operating force, in the same manner as the jaw. Consequently, in examining the arytenoid, we find that the angle of the arytenoid upon the cricoid compels certain angulations elsewhere. In the thyroid these angulations refer to its position in relation to the fifth cervical vertebra of the spine; also its position of reinforcement and adjustment in its movements as a perpendicular arc (up and down) from the hyoid to the cricoid, giving the kinesis of adjustment for intensity and amplification.

Furthermore, as the false cords are attached to the upper portion of the arytenoid and around the sides of the thyroid, we have the arytenoid acting as an adjuster of every motor force applied to the under side of the cords, regulating them in every direction and manner, creating resonance-space for the many diversified currents (arising from the overcasting of epiglottis, cords, and arytenoids) that come and go in spiral ray thrusts from such a source. It also controls and regulates the return of these reflected and reverberated sound rays or thrusts to the sonoric cavity and determines the manner in which their force shall be moulded when regulated on their return by the upper or resonance side of the vocal band, which they contact.

Thus we have explained the three planes of the cords terminating in an apex in the anterior portion of the thyroid at a single point. Nothing could be more accurate than this adjustment from a scientific standpoint, for it explains the peculiar pyramidal form of the cricoid with its circular aperture in its horizontal situation terminating in a circular aperture of an entirely different angle of exit; and at the same time this explains the peculiar placement and angulation of the parts above; also, the intricacies of the resonators and pyramids, hollow, flexible, hard, and movable, which so long have mystified the student of Vocal Art-Science.

We have explained the complexities of the apparatus to which the rima glottidis is attached as it is by its own system of overcasting fibres, which bind its elements. Acting automatically as does the mouth, we can apply the identical rules for its operation as employed for the mouth at "Ah." In other words, it forms a natural opening and closing sphincteric aperture.

When it is closed in an attempt to make sound, you will see from its structure, that it acts like one-half of the mouth for its under surface. This act of closing causes a joining of the arytenoids, and as the arytenoids join we have also the closure of the false vocal cords. Anything in the nature of a sound that will start vibration in the body, opens the glottis as for "Ah."

As our whole system is based upon automatic muscular combination of the nerves, guided by the initial impulse of the vocal nucleus in the brain, we shall find by further study the diaphragm has a sympathetic nerve-control over the entire respiratory or pneumatic region, and also a motor nerve-control of the dynamic unit. So closely wedded is this to the great sympathetic system, that the initial force to produce voice must come from this region. In other words, that which makes a vibration with the glottis in a free position and at attention, produces sound; and thus is the very essence and inception of voice.

Singing, not merely vocalizing, refers to the precision with which the artist places a perfectly conditioned tone in the exact place it belongs in the musical composition—on

the beat, so to speak. Breath-leakage spoils attack. Treating a consonantal value as a vowel spoils attack. Ignorance of dipthongal analysis spoils attack. Unreadiness, uncertainty, over-eagerness, spoil attack. All the singing-exercises in the world will not build a voice correctly unless used as technique, after Vocal Art-Science development. In a word, attack means unifying all the elements of which a tone is composed—thought, feeling, breath-control, phonic utterance, everything—into one pyramidally created effort, which, as this whole work goes to show, is nothing more than a definite breath-clutch and tone-impingement centre.

This constitutes the vocal act, in its elementary analysis, a mental concept, materially expressed in sound, according to the fundamental laws which govern light, the source of life.

Such an attack is a perfectly logical and correct procedure.

CHAPTER VIII

The Vocal A-B-C

In singing, the voice is an interpreter of human consciousness by means of different sounds.

All would-be singers, and no less all would-be speakers, however mature — indeed the more mature the more surely—must again go to school to learn their A-B-C.

Little do we dream as children, when memorizing the alphabet, that its twenty-six components are the material from which the whole structure of organized language is created; that combinations of these components, with the modifications found in other tongues, carry the whole burden of thought and feeling possible to humanity.

The written alphabet.

The written alphabet may be defined as a series of signs or symbols by means of which the eye receives the sounds employed in articulate speech and song. The combinations that can be formed from these sound-signs are as innumerable as are the objects they describe, the phases of human experience they relate, and the states of human consciousness of which they are the record.

A perfect alphabet would include all simple sound-symbols that can be conceived. None such exists, because not one expresses or presents pictorially all the sounds that occur in nature's language.

As students of the alphabet are aware, no nation retains in perpetuity the same sounds in its vocabulary or the same grammar-forms in speech-structure. Conquest, revision of boundaries, enforced speech, alterations in national habits, climatic changes, increased facilities for transportation, and improved methods for communicating and recording, developments on the line of science and art—all these are potent factors in altering the subtle qualities

of letters and the fashion that in different ages the word itself assumes. Compare, for instance, the poetry of Tennyson with that of Chaucer! Suppose the defiance hurled at the Roman conquerors of Britain by the national hero Caractacus could have been preserved in sound as it has in effect, it would be as alien, as incomprehensible, as an Indian dialect beside the periods put into the mouth of the lyric Caractacus in the Elgar cantata of the same name. So great are these changes that those who search the records have to translate the past into the present in order that the two may be compared. Or, to go less far afield, compare the King's English on the lips of Yorkshire with that of Dorset, Devon, and Pall Mall, and then Glasgow and Dublin! Recall seriatim the accents of Boston, Georgia and Kansas City. Place the living speech of a Mr. Balfour, for instance, beside the no less living speech of a Mr. Dooley! Ask any ten persons in a cultivated gathering to pronounce the five vowels, and hear how many can produce a faultless mould. All these points are important in voice-building, because on the absolute precision with which the elements of speech are sounded, depends the perfection of the entire word, the completed utterance.

Phonographic record of speech-vibrations.

As sound originates in vibration, each letter, being a representative of a special sound-form, may be considered a vocal centre or a speech centre of vibrating force. Furthermore, each letter, according to its sound-property or tone-quality, possesses the power to generate a specific form of vibration. A microscopic examination of a phonograph record exhibits a great variety in depths, widths, and contours throughout the tiny continuous spiral track with which the disc is furrowed. These variations mark the several vibration-origins of the different sounds from which speech is built.

The vocal lips as factors in speech.

The vocal mechanism is at one and the same time a sound-maker and shaper. The vocal bands, the lips of voice, initiate the song and its burthen, in one live thought, one concept, one conscious activation of automatic breath, leaving tongue and lips to carry out and perfect the design. The tongue is so poised, adjusted and balanced that it is

capable of an endless variety of complicated movements. The genio-glossi muscles, which are the chief architects of sound-forms, are marvels of dexterity and speed, lengthening and shortening their fibres, during the delivery of the simplest speech, in ways that for number and intricacy almost baffle comprehension. The lips, also—let any one watch lip-action before a mirror while reciting the alphabet, and note the changes they undergo, from the orbicular adjustment that produces *O*, to the elliptical slit that manifests the sound-form *E*. On the outside of the face, the jaw, with its up-and-down hinge-action and its lateral swing, with its wonderful series of muscles about the mouth, is an important assistant in determining the precision of pure sounds, and of sound-combinations.

Lips and tongue as factors in speech.

The jaw as a factor in speech.

From the contour of nose, mouth, throat and face generally, the expert can predicate with certainty if a person be a singer, and whether the singing voice in a marked way is either low or high. This is because certain anatomical characteristics are found to accompany certain types of face, while the face itself is an index of the voice.

The face an index of voice.

As the alphabet can be referred to geometry, so also can it be translated into terms of light. About two and a half years ago in England an instrument was invented—the Optophone. This instrument resembles a hand-camera with a telephone receiver, and, as its name denotes, registers the phenomena of both light and sound. By directing this doubly gifted and sensitive instrument toward an open window it transmits to the experimenter, through the sense of hearing, the light rays as distributed by passers-by. In a word, what the Optophone sees, it enables you to hear, a discovery that translates the alphabet into terms of light, presenting this to the ear through the several vibration-groups that its elements emit. This feat is actually accomplished through the law that every letter has its own tone-shape or vibrating quality, whether uttered by the living voice or, no less surely, pronounced by the silent light-rays as they pass through sound-figures on the delicately adjusted Optophone. In the initial experiments many interesting discoveries were made, as, for example,

The Optophone.

The blind taught by light-rays to read.

that the letter *N* gives forth a peculiarly dismal sound, most disturbing to the ear, while the sound-symbol *E*, acted upon by light, sounds a perfect chord of music. The wide differences in letter-vibration make it possible for the blind to master the alphabet in a few hours. Whole books may thus be presented automatically by running a ribbon of letter-symbols through a machine, as with a moving-picture film, and interpreted by this wonderful Optophone in the language of sound-light.

Musical flames.

Then there are the phenomena of singing flames, which must not in this connection be neglected. A flame enclosed in an open tube affects the air passing over it vibratorily and thus lifts its voice in song. The sympathy of an exposed flame with music can be of such keenness that, as Le Conte remarked, describing the reaction of a 'cello selection on a gas jet, "Even the trills were reflected on the flame-sheet. A deaf man might have seen the harmony!" That flames are sympathetically sensitive with a selective faculty to the elements of speech, is responsible for most important observations. A photograph of a flame that has been talked or sung to exhibits a kind of inverted shorthand record of the speech or song, a record in which, contrary to written procedure, the articulates commonly called consonants are suppressed, a syllable being represented by its unimpeded or vowel sound alone.

Vowel-waves reach a velocity of 1170 feet a second; consonants are only little puffs of air preceding or following them.

With this wonder-tale before us, is it too much for Vocal Art-Science to insist that its disciples shall learn their A-B-C? Only by intoning and pronouncing with accuracy each letter can we "pluck the heart out of its mystery"! From the elements of speech we lay the foundation of voice-rhythm, on which we build beauty of tone in speech and song.

Alphabet mechanically considered.

The alphabet, mechanically considered, consists of breath-emissions, modified by muscular control. A very slight approximation of the glottic lips gives a faint, whispered aspirate. A further approximation yields the hoarse utterance of fear and the sinister emotions. The

completed vocal act makes voice, at the same time shaping it into the elements of speech.

Vowels and consonants.

These speech-elements are commonly divided into vowels (from the Latin *vox*, *vocis*, "voice") and consonants (from the Latin *con*, "together with," and *sono*, "I sound"), the former being defined as simple elementary sounds capable of being uttered alone, while consonants, as their name implies, depend on vowel-assistance to make themselves heard. The classification is misleading and the definition in one instance wide of the truth. Certain consonants have a vowel-value as such in certain combinations; and all speech-elements by their very nature are vowels, in that each is capable of producing its own sound alone.

Alexander Melville Bell.

Alexander Melville Bell rechristens consonants as *articulations*, because they at once separate and join, or articulate, the vowel-sounds which are the fabric from which speech is made. However, traditional names will serve, provided these are accepted as names, and not as exact differentiation and description.

Speech-elements defined.

Vowels may be defined as sounds that pass freely through the open mouth in some position or another; while consonants are breath rendered audible by some action on the part of lips, palate, or tongue. A vowel, again to quote Professor Bell, is due to the open *position* of the oral organs; an articulation, or consonant, is the result of an open *action* on their part.

Speech-elements fundamental.

The subdivisions in which these speech-elements have been arranged by various writers are many and conflicting. One fact, however, has been proved beyond peradventure or dispute; whatever their classification, their vocal regions or autonomies are organic and fundamental. Never may these be treated as arbitrary or adventitious. Never may they be regarded as extraneous matters, to be studied apart from pure voice.

Speech-elements integral.

Voice and vowel are identical. Speech-elements are integral and are as much a part of the creature make-up as hands, heart and brain. Voice itself is speech.

In a detailed study of these alphabet-components, vowels must come first, for the reason that they constitute the elemental utterance, the sound-vehicle of the

emotions. They also come first in the natural process of life. Does not the infant cry upon a vowel? "A hint," sapiently observes Prof. Wesley Mills, "to all teachers of voice-production."

Various theories of vowel-formation.

To account for the formation of vowels, three theories have been from time to time advanced, yet only to be disproved in the light of later investigations. Briefly to enumerate them, they are that of Helmholtz, which is classic; Hermann's, a modification of Helmholtz's, and the cyclonic theory of Dr. Guillemin. The first theory finds, in effect, that each vowel demands for its production a fixed and unvarying position of the supra-laryngeal organs of voice. Dr. Marage, however, has demonstrated that the buccal cavity is capable of assuming many forms for the making of the same vowel, so that this view may be abandoned. Hermann concludes that a vowel is an oral tone intermittent and oscillating. Here logic exposes one fallacy, since, to support such a conclusion, part of the sought-for proof must be assumed in the premises. A further fallacy is brought to light by means of an apparatus modeled on the plan of the human labyrinth of sound-making, which shows that a vowel cannot be reconstructed from the components into which Hermann's conclusions have resolved it. "While from a mathematical point of view his method is objectionable," says Dr. Marage, "so much cannot be said for it acoustically." Dr. Guillemin propounds the theory that "vowels are due to the whirling air-currents, or cyclones, formed during phonation in superior laryngeal cavities."

Dr. Marage.

Vowels and resonators.

Following up the explosions that force their way through the resisting larynx, we find that they disperse themselves in the cavities above. Thereupon, the oral unit, formed from the sonoric region of the voice-tract, adjusts itself sympathetically with the laryngeal vibrations in order to perfect the vowel born below. By the number of intermittencies, the tone, consisting of a fundamental and harmonics, has been created, and put forth in vowel-shape. By the selective quality of air-cavities, these components will be reinforced by organisms capable of vibrations synchronous with their own. Such an organism is the buccal

cavity, which, with its elaborate equipment of lips and tongue, its manifold devices for transforming its hollows into innumerable contours, now becomes the matrix in which the plastic vowel-shape finally is cast, but not, however, without resonance in kinesis. An active, conscious resonator, under muscle-control, such as the buccal cavity, decides the success or failure of the vowel put forth into the world of sound. Its mechanical adjustments must conform to the requirements of the laryngeal tone with its vowel-burden. If the latter is registered by one vibration-period, then must the buccal cavity reinforce it by putting itself in unison with the fundamental tone. A vowel of two periods will call for resonance in the second harmonic of the tone, while experiment proves that nothing but the third harmonic will satisfy the resonantic claim of "ah," the child of three periods.

Harmonics and vowels.

"If the buccal cavity places itself in unison with the sum of the vibrations, the vowel is well rendered; otherwise, though it still exists, it is disagreeable to the ear," says Dr. Marage; while Lefort phrases it, "A vowel badly emitted is a false vowel for which the mouth has not the proper form."

Lefort.

Expanding our definition so as to include both laryngeal, vocalic and resonantic agencies in the formation of vowels, it may be said that vowels "are produced by a series of intermittent aero-laryngeal vibrations, reinforced by the buccal cavity through adjustments, by which this puts itself into unison with the sum of the vibrations, this sum giving the fundamental of the note on which the vowel is emitted, but not without nasal resonance in kinesis.

If the buccal cavity operates alone we have the whispered vowel. The larynx operating alone produces the sung but unresonated vowel. Together the two yield the desideratum, the enunciated vowel, in a condition to be articulated with others, whether in the speech of social intercourse, of oratory, or in the secondary speech of song.

Vowels originate at the glottis and eventuate upon the lips, while the articulates or consonants are supra-laryngeal modifiers of sound. The office of the consonant is to define

boundaries, to mark outlines in a congeries of vowel-sounds, and at times adding to sound and imparting a value similar to the instruments of percussion in an orchestra. With their fellows in the alphabet their regions are organically placed by evolutionary processes that have brought complexities and subtleties to the primitive utterances of animal life. The emotional office of the consonants and their psychic quality cannot be dissociated from that of vowels. Vowel and consonant, in Vocal Art-Science, must be studied from the standpoint of adjustments through muscular control; adjustments for position, adjustments for action, and adjustments of the body in its parts, so as to become automatically balanced.

Following up the pyramidal and prismal principle which we have established as governing all creative effort, and all utilization of life-energy, we find that this is carried out in the formation of speech-elements, each of which in form is referable to sectional cutting of the cube.

The centres of speech, we find, are automatic. The first part of formation begins with the direction assumed by the upper lip, and the depressed movement of the lower. Every vowel-formation is the base of a pyramid, as it issues from the oral sphincter, and, if its projection was visualized, it would appear to eventuate in the apex.

Consonants give an indentation of the vowel-form by which it is recognized in singing. Air cyclones begin with a consonant. If measured by the draughts of air they create, the sizes of these would give the indentation on the vowel-element which distinguishes them one from another. This indentation should precede the actual tone-emission, as far as the adjustment is concerned. Many singers forget that there is a danger of lingering on the initial consonant, the effect being to keep the mouth opened, or to leave it opened imperfectly, on the vowel. Singers therefore are advised to bound off the initial consonant, and to get the mouth open in vowel-position at the actual phonic effort, and furthermore, not to anticipate the final consonant.

In singing, the vowels are the union of the senses, the conveyors of emotion. By their relation, muscularly, they

are sensory tell-tales toward eyes, ears, and nostrils. Vowels and emotions, formed in the mouth and in the oral sphincter, are correlated.

It is through the alphabet, with its combination of vowels and consonants, with correlation of the autonomies or centres of force and muscular coördination of the mechanism, that expression in speech and song is possible.

Vowels are resonators. The geographic location in the human structure shown in our chapter on autonomies, defines the natural order in which their inherent pitch-property occurs. This is susceptible of definite acoustic proof and of physical demonstration. With the fingertip on the Adam's apple one feels the vibration in singing our glottic unit "Ah"; but if this be changed to "E," for instance, the thrill is minimized at that point, while the nose, the highest reverberator, is found in active response. Deaf mutes, deprived of the phonetic appeal, but taught largely through eye and touch, at first pronounce each vowel on a separate tone.

Language, through the alphabet, incorporated into the pyramidal scheme of automatic action by which voice-intention (mental concept) becomes song, calls for absolute perfection of mechanism in order that the ends of phonation may be achieved.

Language, speech-elements, articulated into words, sentences, or thoughts, persist in unseen forms about us. As Professor Babbage has truly said, "The air is one vast library on whose pages are forever written all that man has ever said or woman whispered!"

It takes the higher consciousness of the senses to comprehend the alphabet, but when used in vocalism, as a series of sound-media, it must conform to the demands of a standard capable of being inspired by the soul, reasoned out by the mind, and practised by the body. This standard is the inner ear of the singer, which automatically combines power, resonance and pitch so as to make voice a living fact. Our Vocal A-B-C is the series of human prisms and pyramids measured by the circle of eternity. For, "I am the Alpha and Omega, saith the Lord God, the beginning and the end."

CHAPTER IX

The Vocal A-B-C

(Continued)

To reiterate, vowels and consonants eventuate at the lips. Vowel-sounds have a maximum velocity of about 1170 feet per second; consonants or articulates are little puffs which precede or follow the vowel.

It is through the alphabet, with its combination of vowels and consonants, depending upon the breath after its passage through the entire physical apparatus concerned with voice-production, that the definite training of muscles in coördination and the correlation of the autonomies or centres of force become practical. For the alphabet, as employed in Vocal Art-Science, shows us the coordination, correlation, connection and purpose of every muscle and of all muscles employed to produce communication through the voice, whether in speech or song.

Does it not seem that for the alphabet to have been given us as it is constitutes a divine miracle; although a renowned author says that our alphabet is irrational and illogical and should be replaced by a new word-alphabet? For here, as elsewhere in our theory and practice of voice, we find a demonstration of the union of the function of psycho-physical elements so essential to Art and Science. Everything of emotional nature is corroborated by muscular effort governing the organs of the senses. Such are the tell-tale muscles toward the eyes and ears—muscles which are also visibly used in vowel-formation. These muscles furnish a capital instance of the correlation of the physical and the emotional, so that one may state that, as vowels and consonants eventuate at the lips in voice, so, through the same or part of the same kinesis, do the emotions become manifest.

If vowel-formation eventuates at the lips in the finality of artistic tone-production, then to understand the material mechanism of the artistic tone-finality is the

solution of what we wish to discover. The voice's own portrayal of its manifold emotions, will unfold the story of the relation of vowels and emotions in the aerial world of sound. Our problem deals with the skin of the face, the aperture, muscles, nerves and blood-vessels of the mouth, and their adjacent interested companions, namely, the jaw, teeth, cheeks, palate, nose, eyes and ears. Every nerve, blood-vessel and muscle is in some way involved in its final action, and either manifests itself in the magic crowning wreath of final artistic vocal expression, or is expressed by it. As Fulgentius declared of Apollo, so we say, for example, of the teeth: What better sounding-board than they? And what of the lips that cover the teeth as flexible and adjustable regulators of resonance?

Repeat the seven vowels, ē, ā, ī, ah, ooh, awe, oh, and watch the action of the moistened lips and tongue upon the solid bony resonators—the teeth. Observe the four median raphes, or spliced central muscles, work, especially on the upper lip; namely, those that join the orbicularis oris to the aperture of the nose, that in so doing unite the senses of taste, smell and sound as a psycho-physical whole at the arch.

A vowel-form is always concave upon the lips. Watch the other single muscles of the lips working in pairs, symmetrically and conjointly as they make the consonants, but always in convexities as they clothe the vowel with its psychic wreath of projections in the correlation of our five special senses. The very nature of it all is revealed at once in the consonantic puff, on the contour of the lips, or the dimpled raphe or spliced muscles at the centre and corners of the mouth in vowel-production. Without these movements of the lips, dropping of the jaw creates "Ah," or the unit of initial procedure of voice. This first unit, "Ah," put in action, reveals the natural, vital, blood-and-nerve-supplied lips, parted and ready for action with absolute lack of muscular lip-control. The next vowel is "Ā." Here the upper raphe or spliced muscle, composed of the two central pyramids of the upper lip, is drawn up.

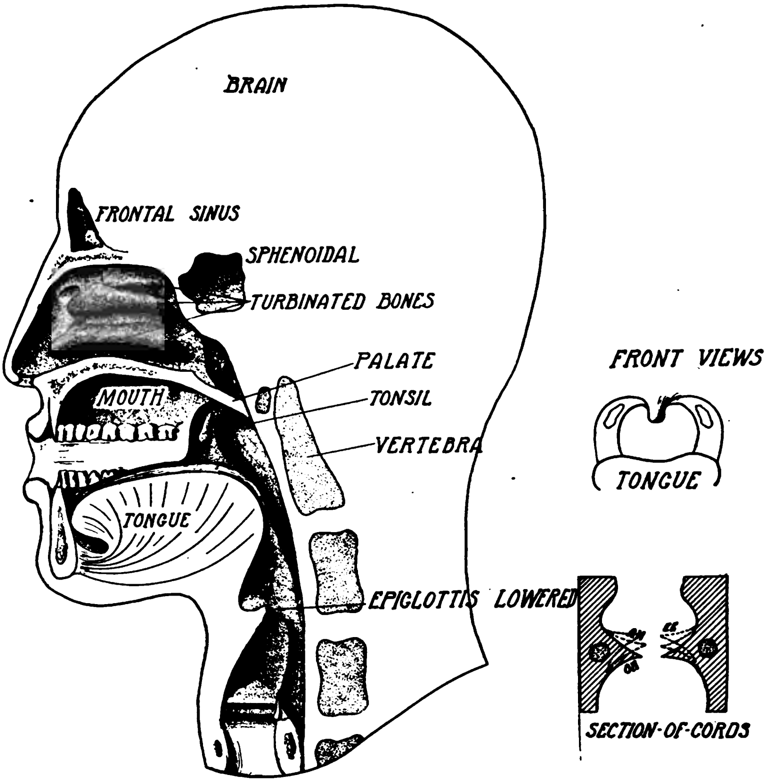
Before dropping the jaw everything concerned in the process of speech-formation is at right angles; when the

jaw is dropped it alters these spaces into hollow adjustable resonant pyramids capable of meeting all the demands of the laws of acoustics.

In the next chapter every letter of the alphabet is analyzed. Because of the importance of "ah" as the initial unit, and the action and adjustments necessary in its formation, from aperture of lips to aperture of the vocal cords, it demands special study.

In Vocal Art-Science, the alphabet, instead of being a mere sequence of determinate symbols, thus becomes a living, breathing scheme for communication of man to man through speech or song. However specific the investigations of those who have attempted to deal with this subject, the results obtained are incomplete, for the reason that they were unaware of the formation and method of functioning of the human vocal apparatus. Vocal Art-Science has opened a pathway of discovery of these fundamental factors in voice-production, and is able to apply the knowledge thus gained with definite results. What hitherto has been obscure, now becomes plain. This science especially illumines the subject by taking into account its discoveries of the sphincteric formation of voice and the coördination and correlation of all other parts of the vocal apparatus engaged in voice-production; nor does it rest here, but reckons as well with the pyramido-spherical formation of the letters with eight definite actions of the vocal cords based on absolute laws of kinesis along the planes of a pyramid. These discoveries make it possible to standardize the scale of letters in voice-production.

To determine the sequence in pitch of vowels and consonants in scales, it is necessary to know the capacity and content of that space in the vocal apparatus governed by the lips, teeth, tongue, palate, and vocal cords. The size of the aperture of the mouth, so mobile and capable of many adjustments, affects by correlation and coördination the adjustment of every part of the space from sphincter of mouth to sphincter of cords. This latter statement can easily be proved by holding a tuning-fork in front of the aperture of the mouth.



THE POSITION OF THE VOCAL ORGANS DURING THE PRONUNCIATION OF THE VOWEL "O"

Fig. 33.
(Karl Kraft.)

As one says "E," "Oh," "Ah," he will feel that for "E" the adjustment of pyramidal spaces from lips to cords is smallest; for "Oh" largest; "Ah" is the middle measurement between "E" and "Oh," so that "Ah" may be called the unit of balance of measurement in the alphabet scale. As a matter of fact, we find that any deviation from "Ah" is progressively smaller toward "E," or progressively larger toward "Oh." Thus we have three letters, three vowel-tones, upon which all other combinations of letters depend; three factors for measuring content and capacity of the vocal instrument and from which can be derived its proportionate content and capacity, and with these its effectiveness in all other combinations. For example, "Ah" being the balance between "E" and "Oh," if the scale of G is used, "Ah" produces a much fuller and more easily adjustable tone at the middle of that scale than would either "E" or "Oh," and can be used as the regulating unit up and down that scale for adjustment. Progressing upward we shall find as we reach the higher notes that "E" is the best vowel-sound upon which to produce the notes of higher pitch both for resonance and compass. Descending, we find that the vowel-sound "Oh" makes the lower tones larger, deeper and more resonant. For as "E" shortens up the sonoric, vocalic, resonantic and pyramidal units, and results in vibrations of higher pitch, so "Oh" extends and enlarges the content and capacity of these units, with the result already noted. In other words, there is a natural progression for vowel-sounds which by their own construction, enable us to take the three that have been named, and, from them easily to mould all other vowels by grading them as follows: For high tones, from "Ah" toward "E"; for low tones, from "Ah" toward "Oh." For "E" is highest pitch, "Ah" is middle pitch, and "Oh" is lowest pitch.

"Ah" being the intuitive and initial unit of procedure for the reason that it is the balance between the two extremes of vowel-sounding, will now be considered in detail. When it is sounded, the lower jaw drops at the angle already stated in vocal procedure. The upper lip curves like an archer's bow. The lower lip adjusts the

orbicularis like a bowstring. All pyramids—solid, hollow, flexible—from palate to lips, adjust themselves according to the law of the aperture, and form a solid, closed lower space. There is also a space, pyramidal in form, along the roof of the mouth, which would be solidly filled by the tongue, did not the dropping of the lower jaw cause a hollow pyramidal space to be formed between roof and tongue. The tongue changes its adjustments downward by the dropping of the jaw and forms, from uvula to lower teeth, the hypothenuse of a pyramid; the base of which is represented by the space open between the two rows of teeth, while its lateral walls are the buccal muscles. In fine, palate, and tongue are so adjusted as to give an equalized arrangement of palate, dome and sonoric pyramids.

The unit "Ah" of each person is dependent upon the content of the spaces and aperture of the mouth. Besides the pyramidal adjustment to the aperture, there is a circle of which the lips may be conceived as forming the radii; the tongue furnishes the radii of another circle from its attachment to the genial tubercle of the chin. At the palate is a circle or double circle, the centres being at the palate itself; the pillars, anterior and posterior, delimit the circumferences; while thyroid cartilage and hyoid bone, in their pyramidal and circular relationship (too technical to be described in detail) combine to produce a hard, bony sector. The next point arrived at in this working out of circles, is the vocal cords where they meet the thyroid in an apex, thus determining their radii of operation. The arytenoid also operates in a circle. The centre of this circle is the tip of the cartilage of Santorini, its point of attachment to the cricoid indicating the circumference. This flexible mass of vocal cord being pyramidal, is therefore in three planes, which also is true of the arytenoid; consequently, both will have three radii. As each is capable of operating for one octave of tone in eight movements, the latter must conform in adjustment for every tone to the aperture of the mouth, where, as we have demonstrated, all spiral thrusts of breath for tone eventuate.

Below this is the cricoid, triangular in form, with circular orifice which by its very shape gives permanent

spiral form to every column of vitalized breath that passes through it.

When we realize the true nature and formation of the cricoid-arytenoid-vocal-cord section of the voice-apparatus, and bear in mind that they are built to operate automatically, and in fact are hollow, compact, flexible forms in automatic action, we have simplified what at first may have seemed a highly complex detail of Vocal Art-Science. Each automatic action consists of eight movements, determined by its proportionate kinetic force working in helical ray-thrusts from pyramids and prisms, which cause the spiral ray-thrusts to move in the geometric dimension of two and a half turns and become perfected in the octave in the ninth evolution of the completed circle. Therefore, it is only necessary to consider each autonomy under its own laws. Thus, considering our cricoid pyramid both compact and hollow, we have breath for tone issuing in helical form from the circular aperture of this cartilage, converted into momentum at the glottis by the bony pyramids of the arytenoid, and developed into pure sonoric sound by the action of the flexible pyramids of the remaining part of the vocal cords. All of the parts just mentioned have voluntary and involuntary power action, some of it antagonistic, but not here analyzed in detail, because in Vocal Art-Science the action of these parts is properly classed as automatic and the parts themselves as autonomies.

CHAPTER X

The Alphabet in Vocal Art-Science

Observing human articulation in speech and song, it is found that from lips to glottis (lips-pharynx-glottis) the action is automatic, synchronous, correlative, coördinate and adjustable. For pharynx, substitute tongue and palate, and we have the correlated actions of all these

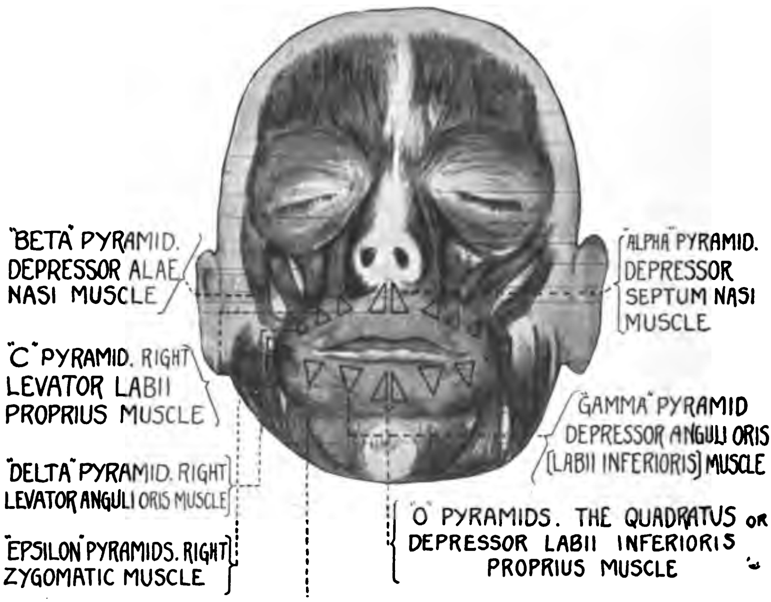


Fig. 34. F Pyramid. Left Depressor Anguli Oris Muscle.

NOTE.—Only the triangular bases of the lip pyramids are shown here.

parts mentioned, eventuating at the lips in articulate speech and song.

These three separate divisions are, as has been shown by the descripton of their circular formation, sphincteric. They function on the principle of sphincterization—opening and closing muscular process—as follows:

I. The lips form the first sphincteric aperture which governs the vocalic unit, and are especially active in the first eight letters or octave of the alphabet.

II. The tongue and palate (the pharynx) form the second sphincteric aperture, giving the articular index for the lingual-sonoric and palato-resonantic units in forming the letters of the alphabet.

III. The glottic sphincter (glotto-voco-resonantic) is the controller for momentum of all the sphincters, supplying their fundamentals, and participates in all vowel-forms.

These sphincters, acting in different planes, yet completely coördinated and correlated as regards their action, combine to form a proper articulation of speech and song.

I. The first sphincter (the lips) works in a perpendicular plane. Its action is divided into that of upper and lower lip pyramid. The combined seven movements of these pyramids control the sonoric, resonantic and vocalic units in their interrelated articulate effort. The four upper lip pyramids index and direct the forms of vowels in correlation. The three lower lip pyramids act for coördination, or are motor controllers.

II. The tongue and palate form the plane of the second sphincter, which is diagonal and inverted as regards the first sphincter. The palate assumes the motor office of three moving forces for coördination, and the pillars and tongue for each for correlation.

III. The glottic or third sphincter acts in a horizontal plane toward the first sphincter and has its three motor actions represented by the arytenoids and its five by the flexible cordal pyramids from arytenoids to the meeting-point or apex at the thyroid. The arytenoids are the posterior terminals of the cords, furnishing the three motor functions for coördination analogous to the lower lip.

Below is the hard bony cricoid with its circular orifice and pronounced pyramidal shape. In the cricoid is gradually compressed the air which has been collected from below, gathering an ever-increasing dynamic power in its outgo through the pyramidal trachea and right and left bronchial cartilaginous tubes. Then coming through the

hard, unburstable circular aperture of the cricoid it is ready for its immediate conversion into articulate and momentic tone in the hollow adjustable pyramidal notch between the solid, bony cricoid and thyroid, the only correct location possible for the safe, accurate and kinetic development of the scale of the glottic sphincter.

It will be observed in the development of the alphabet that, in the vertical plane in which sound travels, three consonants exist between "A" and "E" and "E" and "I," and five between "I" and "O" and "O" and "U."

The first of these, B C D inclusive, may be designated as fulfilling the purpose of correlation; the second, F G H inclusive, that of coördination; the third, J K L M N inclusive, that of articulation; and the fourth, P Q R S T, relate to the breath; V W X Y Z, containing the near-vowel W, and the lingual lateral Y, close the cycle.

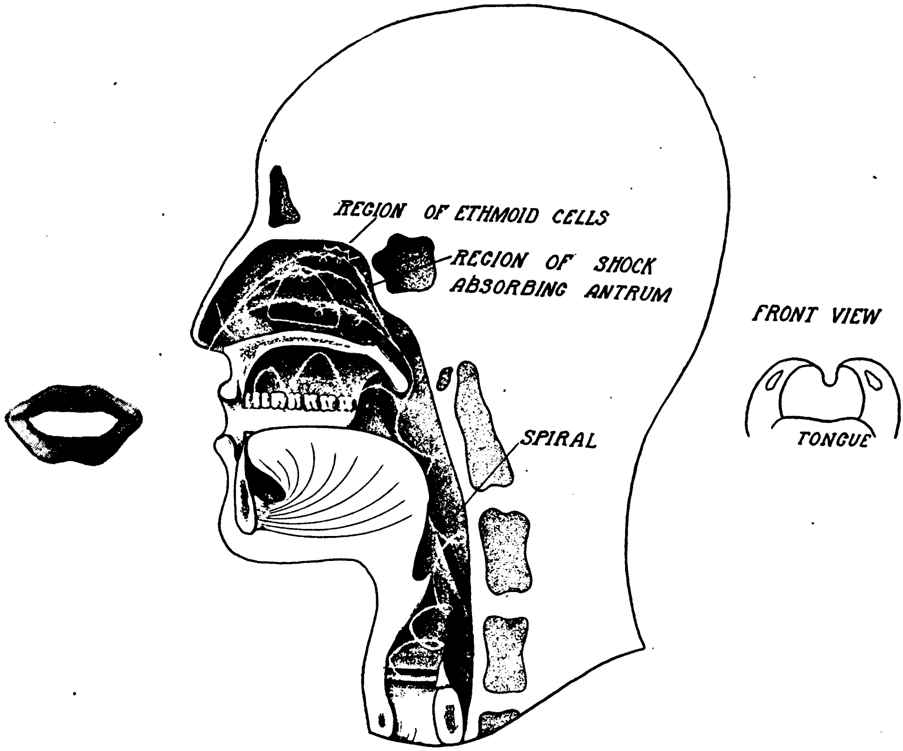
1	2	3	4	5
A (BCD)	E (FGH)	I (JKLMN)	O (PQRST)	U (VWXYZ)

From the viewpoint of articulate speech and song the letters of the alphabet are divided into

Vowels, or self-sounders;
Consonants, or co-sounders;
Nonsonants, or non-tones.

Taking up the letters of the alphabet in their regular sequence, we find the following to be true in regard to the action of the units, from lips to glottis, as the letters are articulated; and if what is here stated appears ultra-technical, it is only necessary to articulate the letters to make the concurrent action of the units perfectly plain and intelligible, for the simple reason that it can easily be felt.

For "Ä" or "Ah," the entire soft palate hangs so far in its middle position, that by means of the palatal elevator it is pulled upwards and backwards. As a result there is left between the posterior pharynx and uvula only a narrow slit, so that the nasal duct is almost entirely cut off from the air-current.



THE POSITION OF THE VOCAL ORGANS DURING THE PRONUNCIATION OF "AH"

Fig. 35.

(Karl Kraft.)

"A" (ā) is made by the slight drawing up of the naso-labial muscles or raphe pyramids. The tip or anterior pyramid of the tongue presses against the lower front teeth. A hollow pyramid is formed by the posterior part of the tongue in connection with the palate pyramid. There is a slight upward movement of the glottic pyramids or vocal cords and of the epiglottis.

"B" is a sonoric consonant and closed mouth vowel, whose explosive utterance is checked by the lips. It draws in and lifts up the lower lip under the upper teeth, especially at the outer edge, while a contact of spine and larynx is accomplished by the protruding centre of both lips from teeth.

"B" is formed by the smelling muscles, commencing with the naso-labial muscles pulling the double raphe pyramids of the upper lip, gathering both lips slightly together and influencing the buccal muscles and tip of tongue. For the latter divides the progress of sound out of the mouth and is known as the levator anguli oris, because it lifts the upper lip.

"C" is controlled by the muscle leading from the eye, along the nose to upper portion of lips as in smiling. The tip of the tongue presses against the upper front teeth. It is the second lip pyramid beyond the median raphe, and is symmetrically placed on each side of it and correlates to the eyes.

"D" is a sonoric consonant whose explosive utterance is checked by the firm pressure of the tip of the tongue against the dental arch. It influences the buccal or cheek muscles and tip of tongue. The mechanism for "D" involves the molar processes which are concerned in resonance. The "D" pyramid, the third beyond middle raphe, correlates with the ear and is an index of the sense of hearing. It is a closed mouth vowel.

"E" is a major vowel. It stretches or draws outwards the lip or spliced raphe at the corners to the zygomatic process, forms a hollow pyramid at each side of the mouth, and divides the vocalic unit into two pyramids. Of these the anterior is smaller, with base against the teeth and two sides meeting, while the anterior third of the tongue

meets the hard palate. The posterior pyramid is formed with base against the pharynx and the two sides meeting at the same place at the anterior third of the tongue.

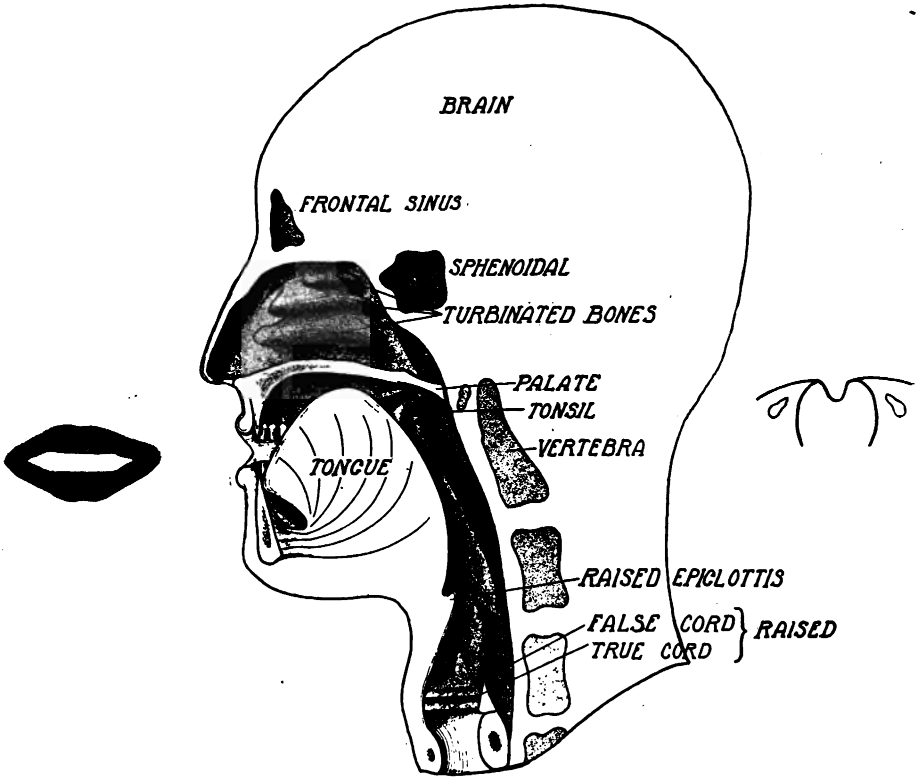
With "E" the soft palate pyramid is drawn up and back, thus reducing this flexible pyramid to the smallest degree, while the two vocal pyramids or cords are elevated to their highest degree, thus shortening the sonoric pyramid. "E" as in "eve," "feet," etc., is the highest vowel; it gives convexed tongue, going up at the back, tip forward; again the buccal cavities are involved because "E," being a vowel, is engaged in resonance. "E" as in "these" has feeble octave and intense twelfth overtone; double-octave mechanism intensity; third medium intensity; and a mere trace of seventh partial. "E" involves special use of the levator palati posterior fasciculi.

"F" is a labial-dental nonsonant. It involves the first pyramid beyond and toward the centre of the mouth on lower lip, progressing from the double "E" pyramid. "F" draws in and lifts up the entire lower lip in coördination with the side masseter muscles; lower lip also drawn under upper teeth; tip of tongue against lower teeth.

Hard "G" is a sonoric consonant whose explosive utterance is checked by the meeting of the back of the tongue and palate, completing the first sphincter combination. A depression of the anguli oris, or labial inferior muscle, moves the flexible pyramid of the palate downwards, and involving the glottis as well as the tongue, brings up the articulation from far below, as can be felt by pronouncing hard "G" as in "get."

Soft "G" protrudes the lips, spreads the sides of the tongue, and involves the glottis by contacting the larynx with the spine. Thus "G," whether hard or soft, focusses the whole mechanism for another action, namely, that of the second sphincter, or palate and tongue. "G" hard or soft has the attributes of a closed mouth vowel.

"H" is the index of the spiritus asper and spiritus lenis. The creation of "H" comes through the mere fact of taking breath (indicated in Greek by a breath-mark). It is a combination of "Ay" and "Ch" soft. Under pyramidal action the psycho-physical breath over the tongue is made



THE POSITION OF THE VOCAL ORGANS DURING THE PRONUNCIATION OF "EE"

Fig. 36.

(Karl Kraft.)

manifest by the lateral action of the tongue pyramid, the broadest sides of the tongue touching the teeth. Breath can be rough, or soft and gentle (spiritus asper, or spiritus lenis). With "H" ends the first octave of the alphabet.

"I" is generally assumed to be a mixed vowel formed of "Ah" and "E". This conception of it is made by the whole base of the tongue; the united action of both lips coördinated with the compound action of double pyramids for "Ah" and "E" and the compound action of tongue and jaw. The double hollow, flexible pyramid made by "Ah" and "E" is compounded by palate and tongue. Diphthongal "I," as in "ice," runs from "Ah," the middle, or balance vowel-tone, to "E," the highest vowel; convexed gives thin "E" as in "feet." The primary action of the first sphincter is exhausted at "I"; the jaw drops in position from "Ah" to "E," which gives voice only to the first octave in the scale of letter articulation. No overtone is detected. On the contrary, this science proves and teaches that there is a definite and separate position for the tongue on the vowel "I"; and develops a shallow groove in the anterior pyramid of the tongue, unlike the arch as in "E." The buccal cavity is enlarged to its highest capacity for tone and overtone. Lips apart; "I" is the intensifier and amplifier of the vocalic and resonantic units and also intensifies the union and action of both pyramids of the tongue by drawing them downward and upward in its adjustments.

"J" initiates a new combination in the use of the two forward sphincters of vocal mechanism for propulsion of consonants, breath being forced out by these two sphincters; it having already been stated, categorically, that the first sphincter is made by the lips, the second sphincter by the palate and tongue. Unlike the hard and soft G, it balances the two sphincters by the mylo-hyoid muscle, which divides the anterior and posterior pyramid of the tongue, and in this manner it allows the vibrating consonantic breath to rush through the two closed sphincters mentioned in the beginning of a new automatic mechanism, which dominates the second octave of our alphabet.

"K" involves the use of the palate and the lift of the base of the tongue, with tip of tongue against lower teeth and pressing forward. The spreading sides form a hollow, flexible pyramid. The base of this is toward the teeth. The anterior and posterior tongue pyramids come together at the junction of hard and soft palate. "K" is back tongue (post-vocalic) second sphincteric articulation. "K" dominates the closure of the resonantic articulation and coördinates it with the vocalic, and correlates resonance.

The indexing of the letters of the alphabet begins with the upper part of the first sphincter, namely, the median raphe of the upper lip; then couples, in sequence of downward coördination and correlating sympathetic autonomies—arriving at the lip pyramids. This procedure is continued until exhausted in light geometrical forms or movements. Because of similar sound-values between certain letters, the eight movements cover the eleven letters, and bring us to the twelfth letter of the alphabet, "L," where we reach the great primary pyramid of the tongue, which gives us a dual sympathetic combination of autonomies of articulation for the rest of the alphabet.

"L" is an upper vocalic consonant, a near-vowel. "L" is the great sympathetic vibration conductor and director. The delicate contact of the tip of the tongue with the dental palate, divides its current of tone and gives it liquid quality. As stated, "L" is the turning-point of the sympathetic mechanism, the middle part of the alphabet, being the twelfth letter and the index of the combination of the sphincters that are to follow and are governed by it.

"L" divides or separates the short "E" from the "L"; for "L" is in the uppermost part of the vowel-space, situated in the roof of the mouth, and seems to be the means of combining the first and second sphincteric action.

"L" starts the use of the second sphincter; and especially the use of the valves of palate and tongue in conjunction with the first sphincter. So far, then, there seemingly has been a play with sonoric and vocalic forces, more than with resonantic. But from now on development of nose and head resonance in the alphabet becomes the chief operation.

"L" presents the tip and whole of the tongue moving forward to the roof of the mouth and resting at the roots of the upper front teeth. All letters following this are formed by dual combinations actually measured by the tongue and controlling vocalic, resonantic and sonoric units as well as the air-currents in vibration.

"M" is a near-vowel, resonantic and capable of continued tone; a pure fore-nasal consonant. The lips are closed, the momentic, sonoric and resonantic regions well opened. In resonance beginning with M the labial and nasal regions are employed. The articulation of this letter shows the lips forward, alae of nose affected by rumblic resonator beyond the vomer, where the tongue, at the junction of the tip or anterior pyramid with the posterior pyramid or base of tongue, touches the arch at the region of the eye-teeth, and also creates in conjunction with the vowels "ah-oh-e" a sympathetic resonance directed through the pyramidal resonator at the tip of the nose.

"N" is a direct impingement of the vocal cyclones against the turbinated bones, and involves in its actions their superior, middle and inferior pyramids at their posterior tips. This letter is a mid-nasal consonant. The momentic, sonoric and resonantic regions are open. The lifted tongue serves as a damper regulating the vocalic aperture. "N" involves the mouth and turbinated resonators by means of the tip of the tongue, which, by its contact with the roots of the front upper teeth, carries sympathetic resonance to the turbinated bones, to the bridge of the nose, and even to the frontal sinuses.

"O" differs from all other vowels in that it causes an inversion of all the lip pyramids.

The "O" pyramid is the quadratus or depressor labii inferioris muscle. It draws the centre raphe pyramid of upper, lower and inverted lip downward and puckers the rest of the raphe downward like a gathering-string. "O" is the contraction toward the centre of the mouth of all the pyramids with an inversion of all the pyramids, both vowel and consonantic, and includes the contraction of the orbicularis oris.

The tongue is hollow, as if the arch had been inverted; the palate drops in consequence and the vibrations pass

through the dome at their fullest capacity. The epiglottis lengthens forward, the glottis is depressed and the vocal pyramids everted. In fact, all pyramido-prismic autonomies are subject to eversion, lengthening and deepening.

The automatic action of the vocal cords or folds at "O" is due to the fact that the arytenoids dip down and out or are inverted to their greatest degree. This lowers the whole vocal-cord-arytenoid formation to the lowest position of pitch; so that, from it, pitch progresses upward.

In position for "O," the second sphincteric combination depresses the pyramid of the palate and the base of the tongue, and is distinguished from "Ah," in which the second sphincteric aperture attains its greatest capacity. This distinction is pointed out here, because "O's" capacity for lowest pitch is due to great length of breath and column, and should not be confused with the amplifying capacity for vowel-breadth due to a greater circumference of breath-column, as for "Awe."

"P" is an explosive labial consonant. Its articulation presses the entire orbicularis oris muscle outward with the use of palate and tongue. It has no sound save that created by the forcing of air from the second sphincter through the first. In forcing the air into the vocalic resonator against the lips, puckered at the two upper and lower raphes, the motor forces, as they always do, precede the air-column and "P" moves direct from pneumatic to raphe pyramids, activating the second and first sphincters in all their pyramidal forms and connecting up all these in the puckering string of orbicularis oris.

"Q" is a combination of "K" and "U," with lip-shape for "U." The pyramid of the palate is drawn inward, the back pyramid of the tongue is restrained, the dome unaffected, "Q" being a post-vocalic nonsonant. It is made by the second sphincter, the back of the tongue grooved, the tip pressing forward against the lower front teeth and the first sphincter. The lips are slightly contracted.

"R" is a sonoric lingual consonant and a near-vowel. A flexible play of tongue gives it its liquid quality. It is made by the air rushing over the palate, vibrating it and

rolling the tip of the tongue by forcing the current of air under the tip against the upper front teeth, thus localizing vibration of palate and tip of tongue in which the palatal pyramid and the tip of tongue pyramid are vibrated by the air.

"S" is a lingual dental nonsonant frequently diphthongal with "H" and correlative with "C" and "Z." It starts at the posterior and base of tongue pyramid. The sound brings all the sphincters into action. This can be readily understood with the sound of hard "C" and "Z." The tip of the tongue then hollows to admit air, but the sides touch the edge of the upper eye-teeth, so that the air, forced through or between this hollow and the teeth, will cause a hissing sound. "S" is made with a puckering string of mouth like short "E."

"T" is a fore-tongue, checked post-dental nonsonant. From "T" on, commences the use of tip of tongue and glottis in a new process of eversion of all the pyramids. "T" also requires first the upper, and then the lower front teeth, and causes a compression of air against the gums of the upper teeth by the tip of the tongue.

"U" is a combination of lips and tongue pyramids, the lips turning outward and tongue scooping forward. The teeth and gums act as a prop or point of resistance to the tip of the tongue in the formation of this letter. It occupies part of the palatal hollow pyramid, involving special action of tensor palati. It is also a combination of "Y" and "Ooh," according to geometrical regression.

"V" is a sonoric labial consonant whose utterance is checked by contact of the under lip with the edge of the upper teeth. It is made by the inward and upward movement of the raphe of the lower lip, and ends in an inverted motion of the lower lip raphe pyramid, the motor portion of the cord closing in inversion. It is also a closed mouth vowel.

"W" is a vocalic-labial consonant—a near-vowel. It is a slightly closed "Ooh" preceded by air sound. It is "U" intensified with hollowed and humped tongue pyramids with mechanism as for "U". It requires three movements, with the tongue and lips involved. The tongue-tip is

pressed forward against the gums of the upper front teeth; the lips are as for "B" until they form as for "Ooh," with the tip of the tongue against the lower teeth. It compels combined synchronous action of all coördinating and correlating forces of the vocal cords or glottis. It is a consonant for controlling sphincterization.

"X" is a short sound "Ĕ," with the clutch of palate and hiss as for "S." It requires a combined action of palate and tongue and a clutching of the second sphincter, and finally the palate, bringing tip of tongue forward at upper teeth while the air escapes between them and the tongue.

"Y" is a lingual lateral and begins with "Ooh-I" and "E." There is an inversion of all pyramids of raphe as for "Ooh"; the tip of the tongue pressing against the lower teeth with the vocal pyramids drawn up in the mid-position between "Oh" and "Ah," and the palatal flexible pyramid drawn upwards and outwards. There is an increasing expansion of the sides of the hollow dome and pyramids. "I" and "Y" are coördinative reciprocal and not equivalent. "Y" sounds a substitute for "I," on the same basis. It requires three movements simultaneously: Lips, drop of jaw, and lift of base of tongue, viz.: Formation for "Ooh" with lips; drop of jaw as for "I"; lift of tongue upward and forward as for "E."

"Z" is a sonoric consonant. Its utterance is modulated by the tone being driven through the nearly closed teeth, the tongue pressing against the lower set, and thus blocking the dental pyramids. As with "E" it accomplishes the highest convexity of tongue, blocking off the dome cavity or hollow pyramid; and also elevates the cord pyramids the same as for "E," thus ending the geometrical possibilities for regression.

"Ng" is a digraph—not a diphthong. It is an elementary sound, a post-nasal, vocalic consonant of the velar regions. All the vocal regions are open; the posterior tongue and palate serve as dampers between the resonantic and vocalic regions. Taken as sound these two letters represent pitch an octave apart. "N" is high, "G," low. Made entirely with second sphincter and is negative to correlation and coördination.

"Th" also is a digraph. It is a linguo-dental consonant as "Th" in "them," and a linguo-dental nonsonant as in "thin"; but it is not related to "T" or "H." It is produced by the tip of the anterior pyramid of the tongue projected through the upper and lower teeth.

"Sh" is a digraph. It is a vocalic nonsonant, or breath sound, a mutual diphthong of S and Y (C and I) SY, CH, SC, and SCH. "Sh" is sometimes also a sound substitute in proportion as it is correlatively reciprocal for CE, CI, SI, SE, TI, XI, XN, SCI, having the vanishing "E" or "U" sounds.

A closed mouth vowel is a sound modified by resonance in a closed oral passage. Distinguished from a consonant in that it has sonoric vibration due to arousing the latent air into activity by means of compression directed toward certain points. It is capable of direction in the vocalic.

The closed mouth vowels are B, D, G and V.

"Aw" gives width and breadth of sphincter, and provides the means of contact with spine. "OOh":—Both pyramids of tongue press forward and are concave and lips evert and contract in sphincterization. (Ah with Aw.)

"Oh," capable of both the gentle and rough breath and having the quality of the sigh, has the greatest depth.

"Oh" as developed by a contraction of anterior pillars of the palate, and tip of tongue pyamid, is concave. Lips are inverted with contraction of all pyramids.

CHAPTER XI

Breath and Vocal Discipline

Voice is atmosphere vitalized, breath made audible and articulate.

Breathing, or in other words respiration, is the sign and manifestation of life. Breath may be suspended, but when it stops man dies.

In the ordinary process of existence we breathe automatically, without being aware of it. Breathing in song calls for special adjustment of the infra-laryngeal autonomies, in order to sustain a well-regulated pressure at the glottic lips. Correct habits must render this adjustment automatic, but until these habits are so established as to be second nature the will, in phonation, must control breath by discipline.

Breathing, or respiration, consists in the intake and outgo of the air about us, constituted by two acts, namely, inspiration and expiration. Inspiration in voice-production must acquire the power of taking in as quickly as possible as large a volume of air as needed. Expiration husbands the supply, doles it out with carefully regulated force, and upon this controlled action voice depends.

Inspiration.

Expiration.

The lungs must be filled with air whenever occasion offers, the amount taken in depending on the amount exhausted. More air can be pumped into the lungs than their actual capacity, since there always is some outgo. They always contain some residual air, a life-maintaining store, the last vestige of vitality.

The initial mechanism of vocal respiration being established by definite training and rendered automatic, it must be brought into harmonious coöperation with the sympathetic system which governs the emotions. This is accomplished by the breath-clutch, a simple automatic act consisting of a slight grip or contraction of the diaphragm and a slight abdominal retraction.

The automatic breath-clutch.

The breath-clutch reminds us first of all that in normal inhalation breathing involves the act of smelling, the olfactory nerve being so situated that it can increase or decrease respiration, and even enable one to pause in expiration, proving that breath is psycho-physical in its secondary use.

After such inhalation, the exhalation that produces the clutch is practised by pressing the right hand, firmly closed, against the upper lip, puffing out the cheeks, while allowing the air-stream to force passage through the closed mouth against the fist, with a sound as of escaping steam. Meanwhile the chest walls must be allowed to take care of themselves, and all other conscious muscular effort must be done away with. As the cheeks swell the expansion of the thorax will be noticed, as well as the obvious clutch below the diaphragm. It is this which regulates the entire breathing tract as well as the vocal organ. The value of it will be felt through voice-training, after free action of tongue, jaw and throat have been secured.

To acquire practical use of the breath-clutch pronounce the word "Hook!" in a decided whisper, twice short, the final "K" very distinct. Again pronounce it, this time holding the "K" a few seconds, then letting go; the centre where the clutch is felt should be between diaphragm and umbilicus. After this is released you will experience a marked inward clutch, with a rebound of the abdomen. These two motions, the clutch and the rebound, develop definite control and support of voice at all times.

It is here that the effort of breath establishes its final automatism necessary to free tone-emission, and the student learns to make the attack that finds its point of resistance at the gums of the front teeth.

The breath-clutch assumes all the burden of the vocal act; it is the centre of emotional control, and at all times the unfailing mainstay of the singer. By it, psychical attributes are added to physical function, and all these, with the sympathetic vibrations, form the telling power of voice.

By this act of inspiration the psycho-physical senses, touch, taste, smell, hearing and sight, are activated, and

re-activated by expiration. Here again we have that combination of the physical and the psychical that is one of the marvels of Vocal Art-Science and which, truly practised, results in a voice-production that is a genuine union of art and science—a correlation of body, mind and soul; the physical, mental and emotional—the three sensitized surfaces of the world-pyramid.

CHAPER XII

Vox Humana

Voice is cosmic utterance. According to the law of life, the human voice is a manifestation of universal energy and puts the material nature in harmony with the divine.

Vibration the law

The law of life, as we understand it, is nature's primal law, from which nothing is exempt. Sunlight, the prismic force, the energy by vibration, quickens the potential, the natural elements which compose the universe. Sunlight sheds its nine rays on the octave of nature's vibratory scale, in rates that range from ten trillions a second for infra-red, to a frequency of about one hundred trillions for ultra-violet. The pendulum that measures the swing of the sunlight's influence shows how it reaches to the extremes of self-vibration, attracting all to its own key, the central point of its arc.

This, the point of rest for the pendulum, is the key of vibration for composite sunlight, and marks the vibration of normal health for men.

An understanding of the law of vibration simplifies our study of all things; it teaches us that light and life vibrate in the same key, and that by putting ourselves in tune with nature's laws we shall absorb true knowledge.

The law of harmonics is simply an amplification of the law of vibration. Nature is one harmonic whole, and vibrates in one harmonious key.

Music of the Spheres.

The metrical motion of the celestial bodies called the "music of the spheres" is a fact that might be sensed by the ear had this not lost its primal keenness.

> There is not the smallest orb which thou behold'st,
> But in his motion like an angel sings . . . . .
> Such harmony is in immortal souls;
> But whilst this muddy vesture of decay
> Doth grossly close it in, we cannot hear it.

Cosmic pitch and human pitch.

So far as can be ascertained, nature places her eternal voice at F, while for humanity, as by experiment we have shown, the normal note is C.

In the most difficult of scales, that of C, without sharps or flats, lies every perplexity that training must overcome. Should it not therefore be recognized as the standard pitch, this tone of human nature that makes the whole world kin?

Piano and vocal organ compared in the scale of C.

On the piano the scale of C shows correspondences with the human mechanism that cannot be dismissed as wholly fanciful; for they are truly exigencies of a basic law. After the first three notes the thumb must change position for the fourth, and again when about to strike the eighth. We find this is what the voice has to do, to bridge a natural break at those same points, without change of quality. These points in singing mark the closure of the soft palate against the pharyngeal wall, and a change and blending of upper resonance. Here the posterior fasciculus of the palato-pharyngeus glides up, associating itself with levatores and tensores palati, so as to allow air to pass under and on each side of the velum. Meanwhile, the velum, with the palate-raisers, has bunched itself against the posterior wall, forming an air-space on either side of the raphe which regulates nasal resonance, or produces nasality; the palate-stretchers arranging this space accurately for the overtones belonging to this region, the remainder undergoes a further arrangement, manipulated by the palato-pharyngeus, as if it were a thumb.

This palato-pharyngeus is the longest muscle in the vocal mechanism, and further corresponds to the piano, with its three breaks, governed by the long, eight-foot tone, as every tuner knows. The problem is how to temper a scale of thirteen tones so that the intervals between them are relatively equal in pitch, and at the same time procure an acceptable progression in all keys. Being a voluntary muscle, and with the sterno-hyoid forming the external agent in fold-stretching, the palato-pharyngeus works in automatic harmony to this end with the crico-thyroids, maintaining pitch. Anything out of order with it, such as cleft palate, destroys fineness

of overtones, changes the entire feature of articulation and demoralizes the whole mechanism, just as the piano loses regulation when its pitch-setting string is out of tune. Truly, it may be called the human C-string, this palato-pharyngeus.

The vocal folds are stretched a little more strongly for each higher tone, and a little less for each lower. But this is not enough; at their octave-tensing, the regulation must be tested to ensure balance of power, resonance and pitch. This is effected by relaxing either or both of two thyroid-tilting, fold-stretching chains of forces, reaching from the base of the skull to the breast-bone. These two systems originate, as we have seen, at the styloid. One, formed of stylo-glossus and stylo-hyoid, we have traced to tongue and tongue-bone respectively. Thence, by the infra-hyoid group (sterno-hyoid, thyro-hyoid, sterno-thyroid, omo-hyoid), they extend their influence to the sternum. The stylo-pharyngeus forms the other system and passes down to three insertions, as follows:

(1) Some of its fibres coalesce with the superior and middle constrictor muscles of the pharynx. (2) Others join with the palato-pharyngeus. (3) The remainder are inserted into the posterior border of the thyroid cartilage. Thence also, by the thyroidal attachment to the sternum, its influence is extended to this lower anchorage. Each group has its own nerve-supply, as the tables show. Sometimes one muscle has a nerve all its own, it being one either of sensation or motion; yet all members of a system must work with the community spirit, in automatic harmony. Vocalists who use tongue or jaw at each change of tone use the former muscle-chain, while those who choose the better plan employ the route by palate and larynx to breast-bone. In either case the voice at the relaxing instant drops to a lower pitch, the mechanism being perceptible in slow movement, but obliterated by rapidity.

Registers. The adjustment of mechanism required at different points in the voice-range breaks this into divisions commonly known as registers, a phenomenon to be referred to vocal evolution. **How caused.** Evolution shows that in birds, where the syrinx is at the base of the tracheal tube, or duplicated in

the bronchi, the vocal mechanism is anchored at the breast-bone, which accordingly is the centre of sympathetic vibration. In man, with the jaw controlling the resonance-chamber of the mouth, and attached by muscle-sets in groups of three to the head, all sympathetic vibrations are directed thither, so that regionally and acoustically nature presents us with two clearly-defined examples of chest and head resonances.

As the singer experiences three distinct physical sensations in producing tones low, middle and high, and as these sensations are records of physical adjustments, three resonances are generally enumerated: Chest, middle, and head. These are controlled by sympathetic correlation and co-ordination, special training for which should begin at the outset, in order to render the process automatic. The

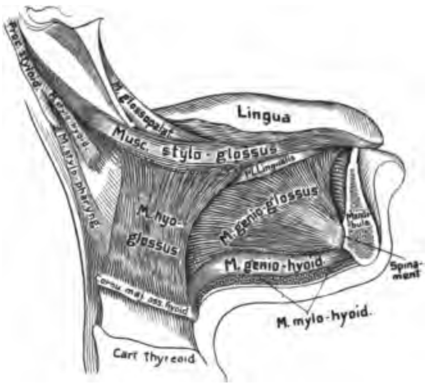


Fig. 38. Muscles of Tongue

danger lies in forming habits by which the part of one vocal autonomy may be amalgamated with that of another, to the disturbance of the entire machine.

Anatomically, resonance can best be explained by reference to the chart of the vocal labyrinth. (See Fig. 37.) Here, at the top of the sonoric cavity, we see a tripartite muscle, forming with the stylo-pharyngeus (which we know as a muscle of fixation), and, what now concerns us, the stylo-glossus and stylo-hyoid. These pass as follows (see Fig. 38): The stylo-glossus from an anterior

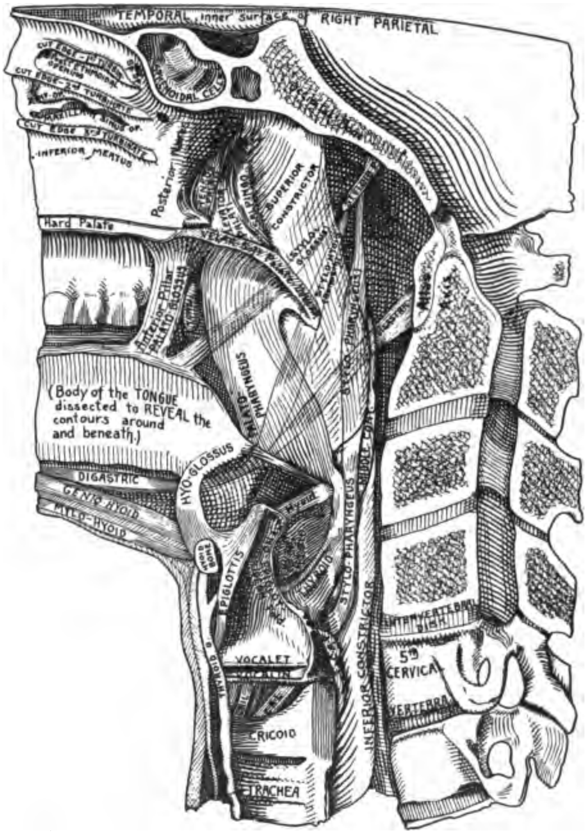


Fig. 37 shows a view of the vocal labyrinth. Attention is here called to the relative positions of larynx and spine.

outside origin, and the stylo-hyoid from a posterior outside origin, to insertions thus: The stylo-glossus at the stylo-maxillary ligament, longitudinally and obliquely in the fibres of the tongue; and the stylo-hyoid at the hyoid-bone. It is this muscle-split that accounts mechanically for adjustments necessary to cover breaks. The terms head voice, chest voice and middle voice (*voce di testa*, *voce di petto*, and *voce di mezzo*) are usually applied to these divisions, and to these, *falsetto* often is added. Falsetto is in reality a bad habit, probably induced by too much tension of the vocal folds, and by displacement of the larynx from its position on the fifth cervical vertebra. As the tension of these folds may be relieved by extrinsic muscles, this false voice could undoubtedly be developed into true tone.

Power, resonance and pitch, the essential trinity in the singing human voice, have previously been described. To these a few other definitions must be added.

Range means voice-extent, scope, compass, up and down the scales. Some voices climb far, while others have but a restricted reach. The true high tone requires increased tension with the development of breath-power and control, as is necessary in all other tone-production. It would be better were singers to refrain from undue compression, and rest satisfied with effortless reach. High tones would be of better quality. **Range.**

Volume is the encompassing power of voice; the space it fills. **Volume.**

Flexibility executes rapid or difficult passages with ease, swells and diminishes no less readily, and gives the subtle accent to style, while a stiff voice can only manage slower, heavier work, and is incapable of manœuvres that call for elasticity. **Flexibility.**

Agility (trills, flourishes) is at home in florid work generally. **Agility.**

Style includes diction and expression, and discriminates between text and voice-production, the understanding of the relative value of vowels and consonants, while discovering the singer's grasp and his ability to convey. By his style we approach most nearly to his mentality. **Style.**

Timbre or klangtint.

Timbre is klangfarbe, klangtint, tone-color. It is generally referred to as white timbre, to describe lack of nasal resonance; dark timbre is the hollow pretense which is the besetting sin of the contralto; sympathetic timbre, when affected as by a glorious color-sensation.

Timbre, klangfarbe, depends in part on the mechanical idiosyncrasies of the artist, and again on the control of resonating influences. It confers individuality on style.

Tremolo.

Vibrato.

Tremolo and *Vibrato* are familiar expressions in the terminology of voice. Mr. H. C. Deacon, writing of the singer Rubini, described him as the originator of the latter, an effect irritating to many people, yet to others so attractive that it was widely copied, especially among the French, thence spreading over the entire singing world. Unfortunately for the artist, however, the violence with which he used it caused his collar-bone to break on one occasion while rendering his famous high C. By a coincidence another singer, Ferri, appearing about the same time in opera, sang with a tremolo which was described as a "ludicrous and incessant wabble"! In spite of this, and though often off pitch, he was nevertheless a reliable artist, always equal to his evening without damage to his bones. Ferri also was widely imitated.

Vibrato and tremolo defined.

Illustrating the two effects with a violin, we find that vibrato is a quick oscillation, caused by a rapid movement of hand and finger, or forefinger, on the strings at a certain spot or division of the board. Tremolo is a rapid reiteration of the same tone by an up-and-down stroke of the bow with the right hand. Again, tremolo is produced by an irregular movement of the right arm, hand or fingers, communicated by the bow to the string at some point distant from the bowing spot. This is controlled by left-hand pressure, which therefore governs the entire resonance of the the instrument. Obviously, resonance and pitch can be accurately regulated by the touch of the left hand at any spot, while power residing in the bowing right hand, at some distance from the string, and with a wide range between fret and bridge to play on, is larger in proportion, though less accurately measured. Vibrato, then, is shown as a

resonance and pitch mechanism, directly produced without predominance of power, while tremolo is a power mechanism, indirectly conditioning pitch, but without predominance of resonance. From this we may draw conclusions that apply to the vocal instrument, as follows:

Definitely applied to human voice. Vibrato ensues when voice reiterates a tone with overdraught on resonance for overtone in any consonance or sequence, this being above or below consonance with its fundamental. It is, in effect, altered pitch, with irregularities in overtone, while tremolo is altered power with pitch irregularities.

Rubini's vibrato analyzed. The irritating qualities noticed in Rubini's voice came from this undue tax on resonance which reflected itself on the vocal lips. As his was a high voice and no beats were ever detected in his octave-emissions, or in his consonances with accompanying instruments, we may infer that his vibrato was sharp, and that in forcing resonance beyond its capacity he broke his collar-bone.

Ferri's tremolo analyzed. Ferri was a heavy, depressing singer, probably because he applied breath-support and muscular coördinations irregularly, sometimes balancing power and pitch, but in general summoning breath slowly and tensing the muscle-control of power, yet falling away before the balance was completed. His being a low voice, the beats complained of in his octave-emissions and consonances with accompaniments, could be more readily detected than in the case of a high voice. That his tremolo was flat came from the lack of breath-support necessary to maintain unvarying pitch.

Pathological conditions of vibrato and tremolo. Vibrato is more common in high voices, and is the more irregular, its own frequency being greater because of its higher pitch. As its mechanism governs resonance, it is apt to be sharp on stress and attack, and flat on finish, with sharpness of overtone through overdraught on resonance. Originating directly at the glottis, the rapidity of its vibrations irritates through irregularity in intensity. Being affected by momentum of both resonance and pitch, it is more common when colds occur in the world of song, or other troubles in laryngeal and supra-laryngeal parts.

Tremolo is more common in low voices; it is slower and heavier because produced by power-mechanism, which, if indirect, results in further slowness and irregularity of vibration. Ailments in infra-laryngeal parts tend to produce it.

Vibrato is local and specific, while tremolo is constitutional and general, a chronic affection in vocalism.

As the two hands of the violinist, the one, as it does, governing resonance and pitch, the other through the bow supplying power, coöperate to produce a single tone, it is conceivable that, at the psychological moment, a subtle communication will pass between the two hands that unite the tremolo of the oscillating finger-tips with the vibrato of the up-and-down swinging arm into one all-harmonizing thrill, enhancing tonal beauty and sympathy. So in vocalism is the effect produced by an emotion which imparts a tremor, or undulating motion to the entire body of the singer. This being reflected on the audience produces a muscular coördination of power, resonance and pitch, balanced for action, control and sympathy, and affects, at some vital moment, producer and hearer alike with a psychological sensation, a veritable thrill.

Dual forces in perfect singing: practical and æsthetic.

Noticing a tried and true singer of education, above all one who has had experience abroad, it is seen that before singing there is increase of breathing, either in rapid respirations, or full long ones, as if the atmosphere, the very essence of sound, were acquiring fresh life and energy in order to be vitalized for voice. A new force possesses the singer, the outward expression of which is one of auto-suggestion, conveyed by a tremor over the entire body. Then, when perfect control is attained, and the artist is exercising a proper psychic influence upon the listener, there will be a spontaneous, regular vibration, as if dual forces perfectly mated were blending the voice practical with the voice beautiful.

Many persons, recognizing this dual force in voice, have proclaimed it mysterious or spiritual, as indeed it is; but that it can be referred in its workings to a mechanism is but nature's law, the law of life.

After the mechanism of voice is under full control, interpretation comes with the ability to identify one's self

in thought and feeling with the composer; to reproduce the tones of the musician, the words of the poet, in the spirit in which these were conceived. In this the intelligence and common-sense, plus temperament, of the artist, are involved.

Singing, then, presents a tone-picture, through the emotions; the variety of colors, and their depths, depending on the anatomical structures of the resonators, and on the intensity in feeling of which the singer is capable.

No coaching, however admirable, can ever result in anything better than imitation; interpretation is creative and artistic only when achieved by the voice itself.

Dr. R. J. Lloyd, London.

Caruso unique as a singing machine.

The most striking example of structural conditions favorable to resonance is found in Caruso, whom we have cited more than once as the living model for standard tone in man. Dr. R. J. Lloyd, the noted specialist in London, writing in the "Daily Mail," describes him as "unique as a singing machine." The exceptional length of the vocal tube is one cause of this, the distance from front teeth to cords being at least half an inch longer than in any other singer observed, the folds themselves being an eighth of an inch longer than any others measured. Also these folds possess extraordinary vibratile qualities, at his wonderful C# the vibrations reaching the phenomenal frequency of 550 to the second. The wealth of tone is accounted for by the unusual mouth-cavity; the volume and roundness, usually appropriated by the basso, are derived from the epiglottis, thick at the base, but in its upper third exquisitely fine and delicate. The chest capacity also is unusual. But possibly the most extraordinary of all the great artist's endowments is found in the resonance quality of his whole anatomy. "If you tap one of his knuckles smartly," continues Dr. Lloyd, "it gives a higher-pitched, more strongly resonant sound than in ordinary persons, while the material of which larynx and supra-laryngeal structures are built is as that of a Stradivarius violin." Always keenly intelligent in his interpretation, possibly the great secret of the well-nigh magical power Caruso can exert over an audience in his happiest moments is expressed in his own words to the author on

being asked to what he attributes his success: "I sing from the head and heart. When I sing with the head alone I do not sing; I go through the opera like a machine. But with the heart also, I feel happy in my singing all over. I make everybody glad." What a supreme gift, to add to nature's equipment such a perfect training as to be able to make "everybody glad."

Temperament and radio-activity.

Temperament is a much abused term, but Vocal Art-Science must rescue it from the disrepute into which it has fallen. Those who have studied deeply the invisible potencies of nature know that every being emits radiations under mental or emotional activation. It is a well-known fact that all thought and feeling are registered in the subtle medium by forms, numbers and colors.

Universality of Color.

The Creator is a great painter: He colors the races, the animals, birds, flowers. Scripture is full of colors, from the coat of Syrian blue that Mary made for Jesus to the flashing of the stones in the Temple. Life has its colors, from the blue days of depression to the red-letter days when we first learn the meaning of love, reconciliation, triumph, or sacrifice. Just as in the British army and navy there is the consecration of the colors to the services of the king, so there is in all nations the consecration of life's colors to the services of the King of kings.

Guido of Arezzo, 955-1050.

When brought to its highest point of efficiency let the vox humana be lifted up in praise, singing the Aretinian syllables which Guido the Benedictine monk adapted from the hymn addressed, according to some authorities, to Saint John the Baptist; according to others, to God: Ut (now changed to *Do*), Re, Mi, Fa, Sol, La, Si.

1 **Ut** queant laxis — 2 **Re**sonare fibris
3 **Mi**ra gestorum — 4 **Fa**muli tuorum,
5 **Sol**ve polluti — 6 **La**bii reatum,
7 **S**ancte **J**oannes!

(Holy Lord, O Father of mercy, cleanse the stain of their polluted lips, that, freed from their bonds, Thy servants may be able to sing the wonder of Thy deeds.)

CHAPTER XIII

Vocal Pathology

Voice, in singing, depends on the sympathetic coördination and correlation of five units or autonomies governed by the medulla and brain.

Automatic adjustment necessary before laryngeal action.

These five autonomies must be adjusted so as properly to shape themselves for voice with every requisite condition, including that of pitch, before laryngeal action can be taken to produce it.

Depression, general or particular, in any of the hollow spaces that comprise these autonomies, modifying them in size or form, will change the character of the sound produced.

Trouble in autonomies the cause of voice-failure.

Anything which occurs within these autonomies to prevent proper functioning of nerve or muscle, or tends to induce an unhealthy condition of the mucous membrane, such as abnormal growths or formations, inflammations and obstructions, false teeth, swollen uvula, tumors of the epiglottis, or trouble of the nasal septum and turbinated tissues, etc., will interfere with voice-production.

Membranes and muscles of autonomies first to be affected. Their condition reflected on vocal folds.

Years of practical observation have convinced me that nearly all, if indeed not all, defective voice-production depends on the relationship of these autonomies to the vocal folds. The membranes and muscles of these autonomies are the first in the human organism to be afflicted, and resultant sicknesses are registered in the larynx, at the vocal folds, in a manner as systematic as it is unique. From the appearance of the vocal folds a physician often can form a diagnosis, locating the trouble in the autonomies. From this I conclude that these autonomies have far more to do with actual tone-building than is generally understood.

There is now a new discovery by science, in the way of a system within the human body composed of a chain of five organs; the only system that has as its primary

purpose the transformation of potential or latent energy into heat and motion. This is called the kinetic chain. According to Vocal Art-Science, this chain would be involved in what is termed the correlation of the autonomies of the body that come into the system for the training of the instrument for singing and health. Without this correlation, the organs included in this chain are impaired in their functions or development; therefore, an important part is the training of perfect correlation in the child from seven years up.

Deficiency in one of the organs of the kinetic chain causes alike loss of heat, loss of muscular and emotional action, of mental power and the power of combating infection; showing that a chain is no stronger than its weakest link. This again is in corroboration of the principles of Vocal Art-Science.

Coördination of the muscles, according to the Vocal Art-Science system, brings about every possible chance of keeping in proper adjustment every muscle of the body, thereby preventing this kinetic chain from getting any unnatural disturbance or strain and making correlation of the kinetic chain more possible. A balance of both conditions, correlation and coördination, makes harmony throughout the entire body. All voice is subject to the entrance of this principle of kinetic force or energy. Voice, then, is force, or the action of this kinetic pyramido-prismal energy on pyramids solid, hollow, and flexible.

Instance of influence of autonomies on tone-building. Tones added by removal of growth.

As an example of the influence of autonomies no actual tone-building I may cite the case of a well-known operatic tenor who showed a tendency to break in scale-singing, particularly at c^1 and e^1i n the medium voice, with a reprehensible catarrhal quality in all tones above the latter note. The cause was found to be an adenoid growth fringed with stalactite forms of mucous that completely blocked up the pharyngeal dome. The patient's reluctancy to adenotomy was overcome, a little cocaine applied, and with a single sweep of the curette the obstruction was removed. The result was that in ten days the voice had risen from b^1 to the high d^2 with a possible high e^2. This fact proved to me that, if supra-laryngeal

treatment will add five or six half-steps to the range, not only vibrations in the glottis must be responsible for resonance, but the spaces themselves, drawn by muscle and membrane, also play their part in actual tone-formation, however contrary this may be to general opinion.

Autonomies rather than folds accountable for timbre.

It must be added that autonomies, even more than vocal folds, account for changes in quality, including timbre or klangfarbe, in the human voice. Since disturbance on the surface of these are invariably reflected on the vocal folds, it follows that membranous troubles and lack of harmony in muscular action occurring in them must seriously damage production of tone.

Autonomies accountable for segmentation.

So great is the influence of the autonomies on laryngeal vibration that the very nature of this appears to differ in individuals. At times in the production of so-called falsetto only two-thirds of the folds are activated, proving that while fold segmentation has yet to be accounted for with precision, the ultimate solution will lie in the autonomies. In this connection I may note that several baritone voices which have come under my observation exhibit a shortening of the vocal bands for production of the very lowest tones; this is another contradiction of prevalent theories concerning voice.

Case of nasality from tubercle of septum.

A pathological condition in the septum of the nose can cause trouble in voice-production, as was shown by the case of a patient who consulted me with regard to a disagreeable nasality of which he was conscious in singing all words ending in ng, such as "morning." Examination revealed a tubercle of the septum impinging against the right turbinate, causing considerable catarrh, and greatly aggravating coryza, if not at times inducing it. Removal of the trouble immediately transformed the offending nasality into the desired resonance of tone.

At this point it is well to introduce a topic which to singers is of vital importance. Much has been written upon the subject of nodes on the vocal cords, yet I will in a few brief words endeavor to elucidate the salient factors relating to this too frequent pathological condition.

Nodes: Usual theories contra-dicted.

My own experience is in direct contradiction to the teaching of many writers who state that these small dropsical swellings occur only at the junction of the anterior one-third and posterior two-thirds of the vocal lips where octave segmentation occurs. Observation has shown me that nodes occur in the following order: First, at C sharp; second, at G sharp; third, at F sharp; and fourth, at B flat. These keep a relative position in ascending the scale, proving that the tension and increased muscular energy brought to bear in the autonomies in producing the upper tone reflect themselves in the folds, from the arytenoid to the thyroid end. In a word, the higher the break in the voice, the more anterior the nodal development.

Autono-mies' troubles localized by folds.

It is virtually an axiom, that troubles in the higher resonator, the nasal cavity, reflect themselves in the anterior portion of the vocal folds. Improper use of this cavity registers itself in anterior nodal irritation. Disturbances in the second automatic hollow space, the oral or vocalic unit, are reflected in weaknesses occurring at the middle of the folds. The posterior end of the folds records disturbances in the lowest hollow space of the larynx, especially if anything interferes with its normal position in pressing on the spinal column. Axiomatic also is it in my experience, that troubles in the lower part of the body reflect themselves on the anterior portion of the vocal apparatus, and vice versa.

Nerve, muscle and mucous membrane troubles precede laryngeal action and inter-fere with voice.

To these we may add another axiom: That disturbances in nerves, mucous membranes and muscles necessary to automatic action of the larynx will be recorded accordingly, at the sensitive folds; the severity of such disturbance preventing the laryngeal vibrations necessary for proper voice-production.

The method of node reduction by using "maw" or "mah" falsetto focused "dans la masque" while plucking the lips, is, in the author's opinion, impotent to rectify these troubles in the anterior third of vocal folds in which the node occurs, the common bane of singers.

The advocates of the above method proceed to reduce the nodes by phrasing, having patients sing arpeggios, scales and notes or syllables as just mentioned. As anything above c^1 involves only a portion of the vocal

folds in vibration, it naturally causes a falsetto which, as its name implies, is a bad habit.

Various methods of reducing nodal growths discussed.

Nodes of themselves can be cured without use of a knife, and often by rest; but, even so, this is no guarantee that there will be no recurrence. The only logical way to prevent nodes is to train the vocal adjustments to such perfection that there can be no frictional trauma of the cords from any cause.

For inflammation, rest the only permanent cure.

This brings us to the question: Is there a possibility of singing by a method, either correctly or incorrectly, which would cause nodal formation? Does false tone-production disarrange a natural sequence of nodes that can be restored by suitable exercise? Or shall we employ astringents, adrenaline, cocaine, zinc, tannin, argyrol, hæmopixine, calcium preparations, all of which have been known apparently to absorb fresh nodal appearances on the folds? All the methods cited have their advocates. One thing, however, is positive: When acute inflammation exists, combined with infectious colds, and the like, the patient must sacrifice everything to absolute rest. For a stated period specific vocal exercises must be given for the individual case, to correct this condition, and followed by a period of rest. For instance, one case may require stronger palate action; another, positive exercising of the ventricular and base of tongue regions, in order to gain balance of laryngeal pulling and perfect cord-stretching. The organization of a nodal formation, indicated by its size and redness, is the danger-signal that voice cannot be used without great injury to the vocal folds.

Typical instance of node forming.

Node-forming may best be described by citing a typical instance. The patient was conscious of only a weakness on the left side of the throat, near the folds, with a tendency to clear mucous which, however, could not be expelled. Examination revealed a white, cheesy deposit in the atrophied tonsil, several thickened papillæ on the mucous surface of the anterior pillar, with a thickness and redness of the circumvallate papillæ or digestive glands at base of tongue; several papules on the mucous membrane over the palato-pharyngeal fold were observed, and one or more over the ary-epiglottic fold. In such a

condition, when the secretions cease and these papules become irritated through lack of moisture, a sudden tickling is felt, the palato-pharyngeus contracts irregularly, affecting that part of the palate concerned in forming the superstructural, or partial overtones. A sudden spasm ensues, with relaxation of the whole voice apparatus on the affected side, the larynx presenting an akinesis, or subluxation of all parts entering into the formation of the glottis. An experiment made some years ago upon a dog showed that tying off the inferior fasciculus of the thyro-arytenoid muscle caused the middle third of the fold to bulge; yet not at once, but after repeated paroxysms with effort to clear the throat while barking. It was then seen that both inferior and superior cords bulged, and that all intrinsic muscles were in a state of akinesis. Attempted phonation at such times shows that, as if to protect its injured fellow, the sound arytenoid will be drawn across to the opposite side, carrying the fold itself at the arytenoid end, and by so doing furnishing an interesting example of nature's compensations. Oddly, the node appears on the well side more often than on the weakened. In this connection the difference must be pointed out between the tissue of fibroma and papilloma, and of fibrinous development in node-formation. While tonsillar degeneration may not cause nodes, yet I never have seen nodes form without some expression of cheesy deposits from the tonsils.

Careful diagnosis having determined the nature of the tumescent body, the cure, in my opinion, will be brought about by surgery, hygiene, rest, and corrective voice-functioning, singly, or in combination. A Victor record in my possession presents the work of a patient who had been singing two years with a papilloma the size of a pea between his superior and inferior laryngeal folds, extending out of the ventricle. Without resorting to emollients, without taking one drop of medicine, but with carefully regulated hygiene and proper vocalization, the artist was rewarded by the disappearance of the tumor without the sacrifice of a single performance. In his own words, "I formerly abused my voice; I now use it with greatest care!"

An instance of the evils of mere palliatives, occurs in the case of another patient, a prominent singer who is a firm believer in my theories. An acute attack of laryngeal inflammation while on tour caused him to seek aid from a local practitioner, who, with more zeal than understanding, applied a spray of menthol and eucalyptus (much affected by a certain class), which gives the throat a delightful sense of coolness—for a time; but, in this case, cost its victim nearly a thousand dollars in engagements, that could have been saved by sending him to bed for a week or so, and carefully watching his temperature. **Instance of evils.**

A word may not be inappropriate with regard to the promiscuous use of the spray. Since the superior laryngeal nerve supplies motor impulse to the larynx and also sensation through its mucous membrane, the application of sprays to the mucous membrane will first increase muscular tension, and later cause a collapse of the machine to the permanent injury of voice-production.

Rest as the proper cure is further instanced by the case of another patient, a singer in a Catholic church, who suffered so from incense smoke during a holiday season as to be unable to correlate the autonomies needed for upper tones, her voice stopping short at f^2. After a six days' rest an attempt to sing only augmented the trouble, but by adding another secular week to the first, absolutely without vocalizing, the irritation disappeared entirely. **Harm done by sprays.**

My method of diagnosing may here be described; a method as simple as deciding by the sense of hearing from which direction a train of cars is approaching. To the expert ear, I find, the debility of the patient will localize itself, both in speech and song, often with a reaction on the corresponding muscles of the examiner. The patient placed opposite me, I ask him to sing in single tones the scale of E, as this brings in G sharp and C sharp, points vital in changing the autonomies, and therefore indices of breaks (by which I mean perceptible alterations of timbre, in a cultivated singer). A break at either of these points shows whether injury exists at the base of the tongue, at its junction with the pharynx, or with the epiglottis, and whether this has been severe enough to cause a G sharp

node. A break at C sharp indicates possible injury in the region of the soft palate, in the pharyngeal pillars, or at the tongue-base, or else that some follicular enlargement interferes with the reflexes in the posterior pharyngeal wall. A blowing sound in the down-scale between G sharp and E warns us of the thickening of the arytenoid or inter-arytenoidal spaces. In a high voice, the G-sharp scale then is tried, and if the notes above the first octave cannot be reached there is certainly trouble with the pharynx, possibly a post-nasal growth or secretion which interferes with the action of the soft palate. Should the quality of high G sharp be forced, the patient is directed to sing through the nose, and if, by pinching this, nasality cannot be produced, we know that some growth or constriction of the cavity, or calibre, of the nares is interfering with the auxiliary autonomies of the nasal passage. A trained ear, with a knowledge of the units of strength and the autonomies in their structure and function of such absolute precision that muscular reaction can be mentally diagrammed, are indispensable to the diagnostician in vocal pathology.

Valves of resonators.

The cause influencing the resonance-spaces of the instrument of voice is found in the action of its three controlling valves—palate, tongue and epiglottis. About these most medical questions are centred.

Aegophony.

When, as often done formerly, the palate has been removed, so as to form a perfect arch, the ability to form overtones is greatly diminished, and the tone-character is marked by ægophony (from the Greek, *aiga*, a goat), or bleating quality. Even thus handicapped, a singer has been known to pursue his artistic career, though not without impaired success and extreme mental suffering. I submit that there should be a more general agreement as to when such ablations are imperative.

Case of removal of turbinates.

A case in my experience, of trouble in left frontal sinus and antrum, demanded the removal of the hypertrophied turbinates on the same side for relief. Three days after the operation (as has occurred in my practice under similar circumstances), the whole left side of the face and laryngeal folds became partially paralyzed. Three

months showed marked diminution of all discharges, with full restoration to normal conditions as to face and larynx, and the patient sang in perfect voice, with gain in overtone through the opening up of a new resonance-cavity, with clear breathing-space on the formerly affected side. The facial disturbance following the operation I attribute to the temporary injury to Meckel's ganglion above, through its association with the turbinal innervation. But the nerve-supply of the larynx being remote from this, a fuller explanation than I am prepared to offer is needed for the temporary akinesis of the vocal apparatus. Tentatively I suggest that the answer lies in the disturbance to the kinetic system, recently outlined by Dr. Crile, through its station at the thyroid. This case presents another question: Granting that the closing of the postnasal space by the velum causes the four overtones to disappear, coupled with observations made upon 40,000 removed turbinated bones I believe that the turbinates must be controllers of partial resonance for the glottic fundamental, the superior turbinate responding to b^2, the middle to g^2, and the inferior turbinate to e^2. Obviously, from the case under discussion, one set of sub-chambers is capable of assuming the duties usually left to two. When then should the turbinate tissue of singers be removed?

CHAPTER XIV

The Vocal Pathology

(Continued)

Surgical interference a most delicate question for the voice-physician to decide.

The question of surgical interference is, probably, the most delicate which the voice-physician has to decide. Take, for example, the matter of tonsils. Recent research, with its wonderful enrichment of our knowledge of vocal mechanism, has set an obdurate face against what our ablest investigators have branded as the "startling onslaught upon the tonsils." Tonsils, be it understood, include the faucial pair, and the pharyngeal tonsils generally called adenoids. Adenoids are not, as commonly stated, pathological; they are as much a part of the normal structure as are the teeth and eyes. The name comes from the Greek words *aden* ("gland") and *eidos* ("like"), and they belong to the glandular bodies which act as filters to the lymphatic system, receiving germs and other poisonous deposits, and detaining these for the lymph-cells to attack, digest and destroy. Are such health officers lightly to be spared? Yet the swollen condition that marks the normal functioning of the adenoid is sometimes mistaken for unnatural enlargement, and treated accordingly by the crassly ignorant, with results always disastrous, too often fatal. To quote Dr. R. B. Faulkner, the recognized authority on the subject, operations for the removal of adenoids have been followed by "the most appalling list of accidents in the history of surgery." Normal faucial tonsils, no less than the pharyngeal, are necessary anatomical presences. They lubricate the adjoining muscles and offer mechanical compensation and invaluable support to phonation in modifying and balancing the three supra-laryngeal cavities. The tonsils also act as safety-valves for undue secretions developed by the digestive tract. Are such sentinels of the vocal penetralia, such acoustic agents, to be removed without due

Adenoids.

Organs, not an ailment.

Tonsillotomy a fad.

consideration? Never, indeed, unless the last word in diagnosis finds them so diseased, from the atrophic side especially, as to harbor germs and to beget specific infections of a character so menacing that operation is the only remedy.

Case of permanent monotone from careless tonsillotomy.

As Alexander Graham Bell says, "Every change in the passage through which the voice travels occasions a corresponding change in voice quality." One case of many may be cited of a child with a permanent monotone, due to an operation for tonsillotomy where the surgeon, disconcerted by the effect of the ether given, cut off the entire posterior pillar. In time the patient recovered a fair speaking-voice, but without phonetic values, the voice being confined to a single pitch. Bungling execution does not invalidate the truth of a principle. However, this instance is presented to emphasize how often the task of tonsillotomy, calling as it does for the master's hand, is entrusted to a journeyman and results in the ruination of a vocal career, if not worse. As a general observation, tonsillotomy, with a properly constructed Mackenzie tonsillotome, even if applied with force, should not injure capsule and supplementary pillars on which the conservation of phonetic values depends. Injury to these, through the palato-pharyngeus and palato-glossi muscles, is most serious, impairing the action of palate and tongue in speech, and tongue-action in speech and song, and furthermore destroying overtone. In adenoid removals, the post-pharyngeal wall, if dragged off, can be replaced; but should the superior constrictor, the large swallowing muscle, be injured, it would affect the upper register of the voice through the middle and inferior constrictors, which are regulated by the palato-pharyngeus. Take any group of children—patients whose abnormalities have been treated with intelligently regulated corrective vocalism—and compare them with their fellows who have been subjected to a ruthless tonsillotomy. In the former, careful vocalizing has located the trouble, whether in dental arch, enlarged turbinate, or overworked pharyngeal tonsil, and prescribed for accordingly. In the latter, a permanent weakness records itself in nasal and oral mucous membrane, especially

Dental arch trouble corrected by vocalizing.

at the three turbinates, through lack of development and from loss of voice-vibrations on them.

Septum, dome, hard palate, teeth, epiglottis, and thyroid cartilage, are of special value in the production of the overtones of the fundamental. Exercises, particularly in childhood, will correct abnormalities in them, and develop their resonantic office.

To enumerate the high authorities who have put themselves on record as opposed to vocal surgery, except as an extreme measure, would be to invoke all the important investigators, scientific teachers, and singers no less scientific, known to contemporaneous history.

It has been widely circulated among physicians that Adelina Patti had her tonsils removed at the age of twelve. Mrs. Richard Van Anden has stated that she remembers the day when this was done. The late Thomas W. White, President of the Board of Council of the N. Y. Herald, and also its musical critic for many years, informed me that Mme. Patti's New York physician, the late Dr. Ceccarini, personally told him that it was true that Patti's tonsils had been removed. Dr. Richard B. Faulkner, in search of authentic information, took up the subject with Patti herself, and, after some correspondence, secured a written statement from her that one-half her right tonsil had been removed, but she was not aware whether the other one had been touched.

This only goes to illustrate the necessity of knowing and remembering, either by personal observation or by information from the physician, the exact condition of things. The physician who removes tonsils should be one competent in scientific knowledge of voice as well as of medical efficiency.

On many occasions it has been my privilege to be brought, by those in authority, in consultation to singers needing medical attention. In order not to err, I have in many instances been granted permission, by my own request, to investigate the history of facts in the vocal and physical condition of singers. During the régime of Maurice Grau, Heinrich Conried and Gatti-Casazza at the Metropolitan Opera House such opportunities were frequent.

Similar opportunities came through many other New York managers, Henry W. Savage, Shubert Bros., Klaw and Erlanger, Oscar Hammerstein, or their representatives, who, one and all, reposed the utmost confidence in the author's charge of, and advice to, their singers. I made untiring efforts to secure proper reports for record, but almost invariably the conditions as described by the singers themselves were wholly at variance with what I knew to be the case. Often such difficulty is due to confusion resulting from a singer's being under treatment by several physicians at the same time; but there is a general belief among managers, on account of the reluctance of artists to have a report made, that a truthful record cannot be obtained.

The underlying reason for this reluctance is fear—a dread that if any weakness were disclosed it would injure their careers, and if famous, that it might be handed down to their detriment in history. Then artists fear that an examination might be made for the purpose of enabling the management to get rid of them, and the record is made favorable to the management's purpose. In the many times the author has been called in consultation by managers in order to endorse or accentuate the treatment of well-known artists by other medical experts, he can truthfully say that he has faithfully performed his duty both to the patient and the management, and to the advantage of both, by completely submerging his own individuality. The author has been able to do this through his threefold capacity of musician, singer and scientist of voice, which has rendered him capable of judging the exact requirements of the singer. Incidentally, few public statements regarding voice-condition of artists can be relied upon, as they are unauthentic and colored to suit popular taste.

In referring to the function of the tonsil I liken it to a tufted button of old-fashioned furniture. In fact, I consider, from a pathological standpoint, that the function of the tonsil is similar to the tufted button of upholstery.

We all remember how solid and firm was the old tufted-button seat of our Grandmother's chair, and in

what an incredibly short time the old seat went to pieces when we cut out the germ-laden little woolen tuft, answering to the bug-collecting tonsil. This is practically how I look upon the tonsil, and just what I meant to convey when I wrote to Dr. Faulkner on the subject, namely, that the tonsil is the regulator of pillar action, function, and adjustment. To reiterate, the tonsil answers the purpose of a tufted button, and if it becomes loose and frowsy, or buggy, amygdelokelphine the button, but the purse-string and capsule should always be left intact, else the adjustment and function of the human upholstery will be ruined and disorganized or switched into undreamt-of positions by infection, suppuration and cicatrization.

Tonsillar enlargement and other disease, mechanically induced, may be prevented by perfecting the vocal mechanism. Let us hesitate to remove that which cannot be restored; for, as Lilli Lehmann puts it, "Every bad standard of health in the throat can be cured by learning how to use all the muscles properly. Singers who sing will never be troubled by anything." A sage maxim this, and one to be applied to pathological conditions. For all other conditions let us apply the words of Mme. Nordica, "I would let normal organs alone." My advice is, be sure of disease before the tonsil is removed, and, moreover, let us operate and not mutilate.

One of the great demonstrations of Vocal Art-Science is shown by the results accomplished with Miss Lilian Kiel—the cleft-palate case with only a portion of a vomer bone in the nose.

Previous to the practice of the principles of Vocal Art-Science, Miss Kiel was unable to articulate or enunciate in an intelligible way. By careful and definite procedure the cleft-palate speech was in twenty lessons almost entirely obliterated. Both Miss Kiel and Miss Helen Kellar were brought before the Academy of Medicine in New York City in 1912 for purposes of demonstration. The results that were accomplished with Miss Kiel were nothing less than marvelous when it is considered that she was thirty-one years of age before adopting the principles laid down in Vocal Art-Science. She appeared before the New

York Dental Association in New York, and again at the New Jersey Dental Convention at Asbury Park, and yet again before the New York State Dental Association at Albany.

All these demonstrations were conducted before vast audiences of scientists, physicians, and dentists.

In June, 1914, Miss Kiel was taken to Fairweather Hall, Columbia University, New York City, to be tested by the Miller-Hall voice-recording apparatus, one of the most delicate machines known for photographing the relative frequency and intensities of tone and overtone.

Phonetic values were demonstrated and established in each and every test of resonators.

Each resonator was taken up separately and then combined. From the sinuses, the turbinated bones and epiglottis, the register of every resonance was distinctly heard and demonstrated with wonderful clearness. The following most remarkable results were obtained, which would not have been possible in a normal case. Namely, a curved rubber tube was placed over the glottis to obtain the direct momentic sound when all other spaces were shut off, the tube being the only "catch-all" for the first sound.

On examination, after one year's instruction, nothing could be more beautiful than the progress of this case.

The little narrow edges of undeveloped pillars and palate, that heretofore hung so helplessly, were strong, active and without constriction, holding the mechanical appliance in position, which was utterly impossible at the beginning. More than this, a healthy condition of the mucous membranes had been established.

It is through this case that an enormous amount of accurate investigation has been possible, showing how most vital results of correct phonation have been gained for Vocal Art-Science.

Much that could not otherwise be proved in a normal mouth and nose has been definitely established, in a marvelous way, through Miss Kiel. For instance, it has been possible because of the absence of the vomer bone in the nose to show what the resonance through the nose is, when

there is no obstruction. By blocking up the nasal cavities with wax, attached to a false vomer bone on the Mitchell mechanical appliance, now worn by the young lady, supplying artificially that which nature did not, has proved conclusively by the complete lack of nasal resonance what the nose, clear and free in its passage, means for reinforcement to quality of tone.

In a similar manner false tonsils were inserted in this person's throat and a tone sung. By removing these artificial tonsils, voice was again produced, and the change of added resonance that was lacking with the false tonsils placed in the ventricular pockets was apparent to the hearers, and registered by the machine as correct.

With the assistance of the Mitchell mechanical plate device Miss Kiel is able to hold responsible positions that require use of the voice constantly, and no one hearing her would note there was any deficiency in speech or in quality of voice. Her singing ability is marked by musical flexibility and legato, and she sings with expression and splendid diction.

Another case of cleft palate calls for description, since this went far to upsetting the author's theories of autonomies. In a patient this deformity was so fully expressed as to allow the nares to be seen in all detail. Her speech was blurred by the usual shortcomings incident to her deficiency, and while breaks to some extent were noticeable, in singing from c^1 to e^1, at the so-called register changes, yet she was able to sing from a^1 flat to high e^2 without perceptible break, even before a false palate had been introduced, an apparent contradiction that baffled the author till Mr. Wangeman suggested a solution that restored his faith, namely, that the thickened wall which is so prominent a feature in these cases divided the air-chamber in a way to produce the same result as in the normal structure.

In children, during mutation, that is to say, between the ages of twelve and fourteen, the bones of the nose take on a special growth, particularly at the vomer bridge, and likewise all other bones influenced by the pituitary body. For this reason I strongly advise against any

operation involving these parts during this entire period for fear of arresting their development.

A disturbing influence in resonance often arises from the deviation toward the left of the nasal septum which is found in seventy-five per cent of adults and which is liable to occur from childhood up. It is accounted for, according to Sir Frederick Trevis, by the habit of blowing the nose with the right hand action; according to Dr. Robert Frothingham by pressure of nostrils against the breast of the mother in childhood. This could easily be avoided by early training. Indeed, early habits of cleanliness and care would do away with many nose-troubles that specialists are called upon to relieve in singers.

I have called falsetto a bad habit. Certain conclusions regarding it were brought home to me at a demonstration in didactic vocalism before a group of musical supervisors at a university concourse. The director sang falsetto and remained on pitch. When he sang full voice he was off pitch with poor balance; the pitch mechanism was too strong, and the resonance limited to a stiff, post-palatine direction, probably the result of tonsillotomy, which he told me he had undergone. In falsetto, the fundamental is acted on sufficiently to fulfill the minimum capacity of the resonance-chamber; it requires but a third or fourth of the energy needed for full voice, and controls but one-fourth of resonance, and therefore can easily be held to pitch.

When the crowning gift, the voice divine, loses its power, then the singer seeks the specialist, imploring to be saved from ruthless fate. But generally it is too late. Either unsound organs that, if initially attended to, could have been saved, are irrevocably damaged, or else organs originally sound have been injured, sometimes beyond aid, through exercise in faulty methods.

Hygiene for singers and speakers involves the entire being. As Dr. Horsford truly says, "Train the body; physical fitness is essential. Vocal deficiency often means mental deficiency; train the mind."

Dr. Cyril Horsford, Kensington Gen'l Hospital and

Equally true is it that good vocalism means good hygiene through which singers generally become robust.

Central London Throat and Ear Hospital.

Vocal discipline, breathing and correct vocal procedure cannot help but make for health of body, mind and soul.

Not till standards shall have been established and universally adopted by specialists, physicists, teachers and singers, working together for a common good, will Science wedded to Art produce the perfect voice.

CHAPTER XV

Vocal Efficiency

Everything that exists has motion. The earth is in a constant state of vibration, subject to forces of the sun, which answers the same law of impulses. The earth vibrates in one plane, while the sun vibrates in another. The two vibrations unite in the apex of a triangle, thereby forming a point of equilibrium.

Conception, gestation, and birth of the individual are all governed by this law of vibration. The vibratory waves of the child at birth are parallel to those of the earth, but it gradually raises itself, through different vibratory influences, to an upright position.[1]

We will liken these triangles to a state of efficiency because of its completeness and comprehensiveness. There had to be one, two and three forces before the triangle was completed.

Efficiency thus creates the necessity for a standard Vocal system. Therefore we must recognize three vibratory forces as the basis of this efficiency. Hence the knowledge of physiological, anatomical (vocal autonomies and units of strength), and finally synthetic laws, must form the "Triangle of Efficiency" in voice-building or tone-making. The production of a tone is a science, and of necessity based on fundamental laws. How can the vocal student have an intelligent understanding of the true production and emission of a tone, or how can lasting results be attained, unless we accept a definite point of beginning?

The examination of light and voice are analogous. Light may be polarized by reflection, refraction or

[1]As a plane placed on the side would fall unless supported by a third force to keep it in balance, the pyramid of vocal efficiency cannot fail of its purpose. The pyramid of vocal efficiency is more than a mere symbol; it is an absolute replica of the vocal cord by itself which performs and determines the swinging periods of each and every vocal vibration, thus forming the base of a triangle pyramid.

transmission similarly with sound (tone). Polarized light is altered or rotated by its passage through quartz crystal by refraction from a magnetic pole. This is called rotary polarization. Light reflected from metallic mirrors exhibits phenomena which make it probable that its vibrations are in closed curves rather than straight lines. Its polarization is then said to be circular or elliptic.

Vocal tone, in an analogous way, is regulated by a system of polarity or equilibrium similar to that of light. This would confirm the theory that the phenomena of light and voice must be analogous, when one considers that light and voice are both the result of electro-magnetic forces. Light and sound work in different media but function the same way through similar forces.

Light is etheric and vertical; sound is atmospheric and travels longitudinally in its existence. We have two eyes set side by side and two ears widely separated but as symmetrically placed as the eyes. The anatomy of the mouth gives the physical expression of vocal sound, the ears the mental.

Before a clear and concise knowledge of sound production can be obtained the pathway of its development must be considered more in detail.

Vocal Art-Science has established that all sciences (Mathematics, Chemistry, Astronomy, Geology, Biology, Physiology, Philology, Psychology, Sociology, etc.) are built upon a kinetic foundation and are subject in their various and individual forms of evolution to a sevenfold pathway of progression.

Mathematics advances by Arithmetic, Algebra, Geometry, Trigonometry, Analytical Geometry, Conic Sections and Calculus.

Vocal Art-Science develops by a Physico-Biologico-Mento-Psychical process, or a sevenfold progression necessary for perfect tone-formation, as follows:

Coördination—The perfect adjustment of all the muscular efforts connected with the vocal mechanism, i. e., the perfected or specialized static power possessed by each individual muscle-cell and their combination into a physico-biologico-chemical machine.

Correlation—The awakening of the static powers of each individual muscle or autonomies through the controlling and governing action of the mind, which allows distinctive and definite sequential combinations of kinetic muscular forces to come into action. Or, a physico-biologico-chemical-mental kinetic machine resulting in activity, flexibility, and agility of the singing voice.

Equilibration—The resultant adjustment of the opposing coördinative and correlative processes, whereby the various kinetic forces are brought into a physico-mental balance.

Polarization—Vocal polarization or polanization is that physico-mental equilibrated force whereby the vocal sound that is to be orientated assumes a centralized field, having the power of attracting sympathetic vibrations of the voice, to a point which is created, controlled and directed about the tongue the greatest polarizer of the voice.

Orientation—Refers to the position occupied in cosmic space, of the physico-mental equilibrated and polarized vocal sound.

Synæsthetization—The pre-union of the psychical elements with the physico-mental polarized forces (i. e., each of the two elements exists, but as yet they have not converged to a vertex).

Oriento-panæsthetization—The final summation and perception of the physico-mental with the psychical or æsthetic processes that create voice, at the vertex or centre of its entity, built up in the laboratory of the perfectly functioning soul forces, embracing to the fullest extent of its content and capacity the psychology of the individual, the psychology of æsthetic feeling in musical appreciation, and expression. This process embodies as well the psychology of the pedagogy of vocal and all musical function related thereto, resulting in the beautiful technico-soul-perfection of the God-given PERFECT voice.

With the "Pyramid of Efficiency" as a foundation, and the sevenfold pathway as the structural framework, more graphic description of the body of the *Vocal Temple*, must now be considered.

The tissues of the vocal instrument are all pyramidal in form and the expression of their force occurs by way of an aperture at the hypothenuse of the triangular base. (Fig. 39.)

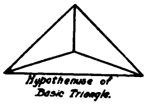


Fig. 39.

Even the brain-cell has bipolar properties; that is, it has two poles on each side which operate in sympathy, bilaterally and symmetrically. They are superimposed in graduated duplicate form, diverge definitely from their apices and are so controlled that all parts act synchronously and in equilibrium. By means of this governing control or polarization the path and direction of the tone have been given, the resonance perfectly adjusted, and all parts are kept in balance, and ready for articulation.

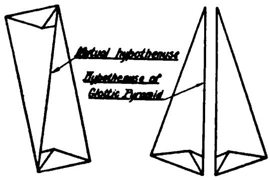


Fig. 40.

The pyramids of voice, or the hollow chambers of sound, may be many-sided, with sides and bases triangular in conformation, as below:

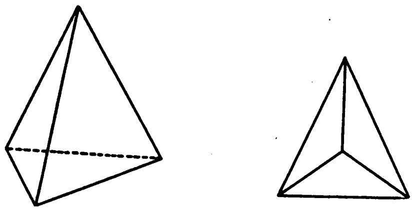


Fig. 41.—First forms of pyramids of vocal efficiency.

These pyramids must be so arranged that the mass of air, when brought in contact with them, develops voice. This requires for perfect development and mechanism the symmetrical placement and arrangement of each autonomy, which in turn controls each individual unit, so that a

mass of air coming in contact with them develops a momentum of a certain speed regulated by the proper adjustment of these parts. Even the mass of cord acted on by the compressed air from the lungs below, must of necessity be regulated by forces made on the same basis from its structure-producing functions, so as to develop, at the glottic pyramido-prismic aperture, forces that act on the same principle and give rise to phenomena analogous to those found in the spectrum analysis of metallic substances, viz.:

First. Intensity of thermal mass, or body of vocal cords; that is, a special thermal activity in the mass, known as intensification of the processes of circulation of the blood in the body-tissues, also to those processes regulated by the chemical combination of the blood, blood-vessels and tissues of the body by pressure, oxidization and friction.

Second. In like analogy we speak of the intensity of luminosity of the mass, or body; that is, the intensification of the process (of interpreting the force or light, altered until it produces the impression) of being equally light with the color, whose luminosity is to be determined and which measures the living force of the altered light relatively as its standard intensity, it then being taken as the luminosity of color; in other words, it is the force in the tissues that alters their action in the matter of position so as to cause it to be perceived in the same manner as it would in terms of light, that is, it produces a sight-form in the voice-producing apparatus that creates a certain ability in the sound-apparatus to detonate pitch sound.

Third. Chemical intensity of the mass, or body; in uniting with the power, resonance and pitch, causes the sonority of voice and its subsequent polarity, direction, and balance or equilibrium to produce vocal sounds at the mouth. By analogy we arrive at the best understanding of the whole question of voice, and find that it depends upon a conception of the correspondences indicated in the nerve and adjacent cellular elements. Each individual cell to functionate properly must have polarity and equilibrium. The summation of these simple cells, and the

extended and united controlling powers of polarization and equilibrium, is then the essence of vocal tone-production.

Therefore, as it is a correct and natural sequence for the brain to so discharge its energy that way in its own perfect system, a correspondence to that correct, natural expression of force, will be a satisfactory system of procedure in Voice-Production.

This particular principle of voice seems to have been overlooked in every system other than that of Vocal Art-Science; and *this* is the pivotal point of standardization of the vocal system.

From the beginning we have made audible our initial voice-sound, through nature, brought about by the natural expression of the contents of the polarized air-cells, set in action by the breath passing over the true and false cords, and sustained by the epiglottis. The epiglottis, in conjunction with its co-planers (the true and false vocal cords, tongue and palate and coördinated pyramidal arytenoids which equilibrate and polarize the very first vocal expiratory sound), affords the efficient means of polarization and balance for vocal tone-production. The next step is to bring the tone out into the vocalic unit—the mouth.

This may be accomplished by creating the intensity of the vibration of the sound of the consonant "M" on the lips by means of the polarizing director, the tongue, which touches the lower jaw where it is joined by the lower teeth to carry sympathetic resonance to the mandible or jaw. For "N" this intensity is created in the same way: by touching the roof of the mouth with the tip of the tongue where the vomer bone is aligned with the turbinated bones, so as to direct the sympathetic resonance in polarizing for "N." By these means "M" becomes progressively coördinate and correlative, and "N" remains stationary and correlative; hence, we designate "M" as positive and "N" as negative progression. By means of "M," sympathetic vocal vibration is conveyed forward to the mandible or jaw; it is carried and directed to upper teeth and the tip of nose by "N". Vocal sound depends for its production

on the sound-momentum established by the differential angle of polarization in its operating sound path. The action of these consonants brings our initial voice-sound forward, both into the nose and the throat. Then, by virtue of deflection, or, for instance, by the transmutation of the sound-waves around the posterior end of one of the turbinated bones (these act as a pole around which the voice-waves turn), they turn and take another and different direction, notwithstanding the fact, that the direction of sound rarefactions and condensations is always longitudinal to the power producing them, or to the *vis a tergo* in mechanical sound phenomena.

Resonance is now wholly established.

The overtone and partial tone-forming space, bounded by the choanæ, dome and posterior wall of the pharynx down to the palate, is utilized in the articulation of the vowel-sounds. The latter process is again governed by the palate and polarized by the tongue, and does not include the turbinated bones, as do the overtones and partials which follow.

The syllabic combination "ng-oh" will give the fourth overtone space.

When the tone is made and its resonance established, its amplification is the next step to be considered. To accomplish this, use the consonant "N" and the sounds "oi," "noi," "gaw," swelling the tone from the "noi" into the "gaw," beginning with the *mezza voce* and amplifying into the *forte* or *crescendo*. The term "falsetto" must not be confused with "mezza voce"—they are widely different. "Elson's Music Dictionary" defines them as follows:

Mezza Voce—Half the power of the voice; that is, softly.

Crescendo—A word denoting an increasing power of tone. It is often indicated by the sign $<$.

Diminuendo—Diminishing gradually the intensity of power of tone ($>$).

Decrescendo—Gradually diminishing in power of tone.

Falsetto—A false or artificial voice; that part of a person's voice that lies above its natural compass.

Thus amplitude or power is coupled with resonance. The resultant of power and resonance is pitch.

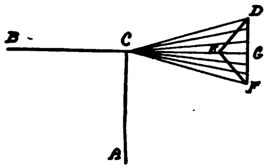


Fig. 42.

In order to appreciate the action of the arytenoid cartilage and its influence in polarization, it is well first to study the action of free nodal vibration in connection with the laws of sound-production, since sound is produced in three dimensions. In the above figure, we raise a perpendicular, A C, and at right angles to it draw B C. Let B C represent a nodal vibration, and when started in motion at a given impulse, it vibrates from B to G in a single vibration, moving in one plane. The same nodal vibration in sound would vibrate in the plane C F D in its perpendicular aspect, in C E F in its horizontal aspect, and in C D G E in its diagonal aspect. Hence, it will be seen that the periphery of its nodal vibration is represented by the triangle D F E, which will be the basis of the formation of the positive pole of this triangular pyramidal nodal vibration.

Assuming the above as the basis and operating pole of one nodal vibration (using this as centre of development), we shall have described accurately the operation of the element of articulation of our voice-producing organ, the vocal cord, taking the latter as our positive pole of the hemispherical sector with its bipolar vibration for voice-production. The negative pole is the pharyngeal pole. It is the pharyngeal extremity of the ligament attached to the cartilage of Santorini which surmounts the arytenoid cartilage which constitutes this negative pole. (See Fig. 43.)

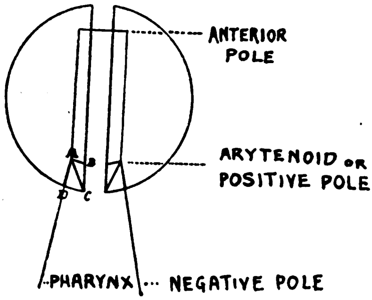


Fig. 43.

If these two poles are placed in the hemispherical sectors and the natural law which marks the force of the sun, gives the universally recognized dextral gyration, we shall have a point where the double polarization will cause an equal adjustment in the satisfaction of the operation of the three sides of this polarization, at the coördinated intervals of two and a half steps (which would be between *mi* and *fa* in the musical scale), and also at the four correlated major and minor intersections (which would be between *si* and *do* as well as at *mi* and *fa*). Consequently, we should have a scale tempered to the ear-drum.

It will be observed that by putting in the angle of the free nodal edges with the arytenoid, as the positive pole, and superimposing on it the pyramidal arytenoid, the whole apparatus is converted into one, similar to the structure of a brain-cell. The free nodal edges are distributed by this arytenoid angle which measures the combined nodal vibrations, instead of transmuting the free nodal vibrations by the hypothenuse of the two planes. The angle is so arranged that the same nodal vibrations in two planes discharge themselves in one common hypothenuse. Such, in the author's estimation, is the solution of the articulation, pitch and balance and polarized elements in voice-work, accomplished by the arytenoid.

When the action of the arytenoids has been finished, and also the mental operation and its physical application of energized breath, we shall find our vocal cords not only hemispherical sectors, pyramidal when in action, but by

the furtherance and completion of this action in spherical relationship we shall find them cuspoidal-laryngeal halves, or hemispherical sectors.

The true and false cords are pyramidal in form; the upper plane of the true cord pyramid with the inferior plane of the false cord pyramid form a hollow pyramidal resonance-chamber or ventricle. The base extends between the free lips of the true and false cords, and its apex, on a line with the external larger arm of the arytenoid, extends forward about the middle of the base of the cords, to the thyroid shield terminating in an appendix of true cuspoidal shape (Fig. 44). Thus explaining the function of the ventricle, in greatly amplifying the tones by this added power to assume greater proportions with the increase of sound, connected with the external sides of the larynx, as noted in the process of vocalization in certain animals.

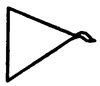


Fig. 44.

When the cuspoidal laryngeal halves or vocal cords are united through the action of their regulating autonomies, and their free edges drawn together, the right cord is smaller, more compact and of sharper delineation than the left; this condition being due to a stronger muscular control upon the right, necessitated by a stronger air-whirl or spiral-thrust produced upon this side.

This hollow pyramido ventricle, then, has within it the requisites of force coupled with the function of the crico-thyroid membrane, to create the initial form of the momentum of power, resonance and pitch for perfect voice. From the author's repeated observations the cords begin to close at one end and finish at the other, in tones or voice-production, and the ventricle furnishes the necessary apparatus for the greatest amplification and intensity of the voice. This shows that voice as produced on inspiration begins at the thyroid end of the vocal cord and finishes at the arytenoid end, and, on expiration begins at the arytenoids and ends at the thyroid. Hence, the only true way to produce a tone by the true cord or fundamental is by voice produced on inspiration.

As both roof and floor of these hollow pryamids, in their finished form, are helically and conically related and

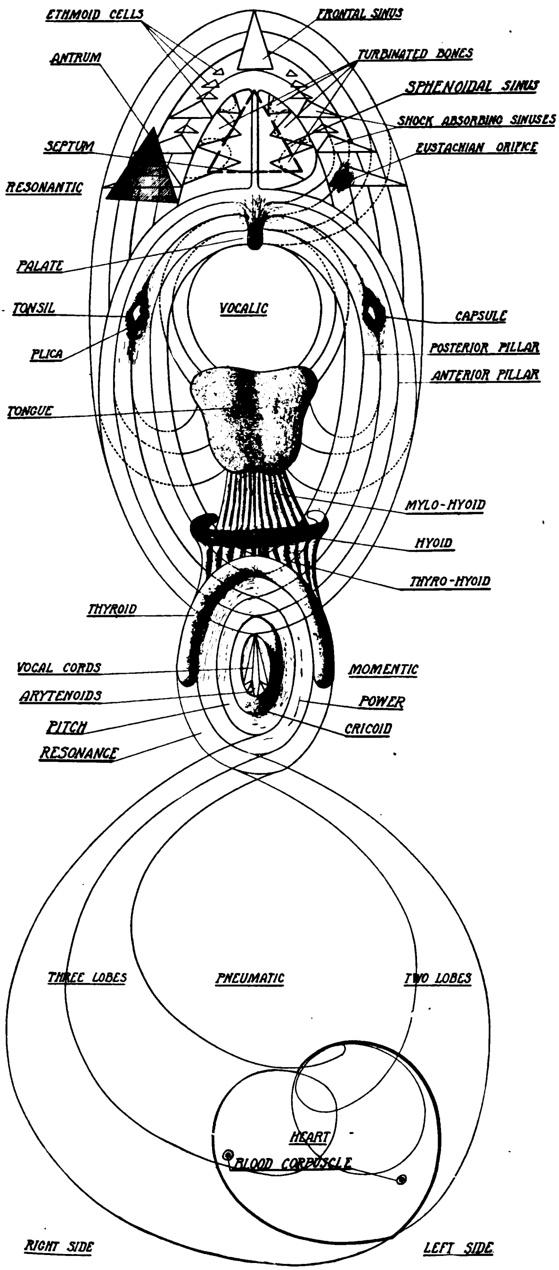


Fig. 47. Pathway of Kinesis.
(Karl Kraft.)

used as units, in hemispheres, tend, when subjected to polarization and equilibration to establish the path of voice. The positive direction of polarization will be in a line with the balanced polarized centre of both arytenoids, and the balanced polarized centre of both thyroid ends of the cords; this will develop a true parallelogram of forces, as follows:

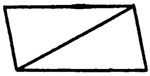


Fig. 45.

The arytenoids, being placed bilaterally and symmetrically on an immovable, solid cricoid, would cause a comparatively perfect alignment of the arytenoid cartilages with the true and false cords in their arrangement as positive poles, and the ligament binding the arytenoid to the cartilage of Santorini and the negative poles in the thyroid ends of the cords; hence, by their structure and situation, they are the only organs that can equalize the polarization and equilibrium of the cords, since the thyroid ends meet in an apex or *abscissa*. This is plainly a proposition in analytical geometry; the result would be the parallelopiped arrangement of forces, as follows:

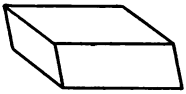


Fig. 46.

After further consideration of the vibratory sound-producing factors, it is essential for a further understanding of the vocal mechanism to turn to an explanation of the Kinetic Pathway.

The Pathway of Kinesis (Fig. 47) is the diagrammatic outline of the vocal tract intended to show the voice-producing mechanism, from lungs to brain. The action of the air from the lungs, its spiral path, its vibration, and finally its reinforcement, all take place within the limit of this "Endless Kinetic Chain" running from the lungs

(which are continuous *via* the trachea with the laryngeal cavity) to the palate, the tongue, and even to the resonatic chamber.

In voice-production all the members of the chain are active. The fact that they are so systematically arranged and connected, shows that there must be some definite relation between the various members. This is true, and is proved by the fact that any minor pathological condition in any part of this tract will materially affect the beauty of the voice, the extent of the defect depending upon the seriousness of the pathological affection.

The centre pathway adjacent to the cricoid, as shown in the diagram, is Pitch, the path nearest the vocal cords. The path immediately adjacent to the foregoing represents Power, while the outside path represents Resonance; the union of the three, Pitch, Power and Resonance, form voice. Nowhere from the power to the upper shock-absorbing sinus region is there a break in the endless chain, proving once more that for perfect voice-production there must be positive connections of the vocal autonomies.

This varied physical structure can be made to muscularly assume and hold, at the direction of the will, a perfectly proportioned structural form, capable of producing the perfect voice. The first essential to perfect voice is the two and a half spiral turns given to the air from the lungs. These two and a half spiral turns are the means by which the polarization of voice is determined. The reason for the triangular shape of the cricoid and the circular aperture at the base is, that the cylindrical column can be best and seemingly only, given a cyclonic vertical or spiral movement by the circular walls of the cricoid.

Modifications of the primal sound must occur as other organs come into play; these modifications are cumulative as the sounds become more complex and varied in their progressive refinement of pitch and tone. Air forced upward from the trachea through the ringed aperture at the base of the cricoid is compelled by the angular walls of the cricoid to assume a motion, regulated by the crico-thyroid muscles, which gives the combined effect of the circle and the angle, and therefore can only be spiral in form.

Perfect voice is produced in the human throat by the cyclonic rotation of air, impelled by spiral rays or thrusts of energy muscularly put in motion and controlled in amplitude and intensity by the physical organs of the throat. The pure tone is produced by the dexter spiral or the cylonic movement, the overtone by the sinister or anticyclonic movement of the air.

Pure tone is entirely cyclonic, that is, composed of all dexter or right spiral rays; the human voice (tone and overtones combined) is composed of both dexter and sinister rays, or centrifugal and centripetal, which in turn correspond to vowel and consonant sound.

From the supply reservoir of the lungs, air is forced up from the large containers through a spirally constructed supply-pipe, the trachea, to a circularly apertured final container, the cricoid. Constantly lessening diameters of orifice from the upper lungs to the cricoid in combination with the ring-structure of the organs, give the upward forced air a cyclonic movement.

In dealing with the subject of Vocal Art-Science it is necessary to use various expressions drawn from mathematical science; hence, that there may be no misunderstanding of terms, several of these expressions are elucidated, as follows:

Hypothenuse is the term indicating the side of a right triangle which is opposite the right angle. Pythagoras many centuries ago proved that the sum of the squares of the arms of a right triangle equals the square of the hypothenuse. The perpendicular cathetus (b) represents the line drawn at right angles from the base or horizontal cathetus or arm (a), which gives the direction; or, in other words, the arm (b) will represent the height of a wave or its point of greatest intensity, (a) represents its amplification, and the line (c) the quality or hypothenuse line.

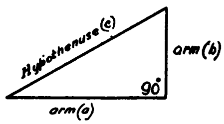


Fig. 48

A *prism* is a solid whose bases are similar and parallel plane figures and whose lateral surfaces are parallelograms.

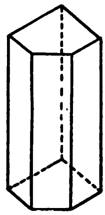


Fig. 49. Prism.

A *pyramid* is a solid having a polygonal base and triangular sides meeting in a point called the vertex.

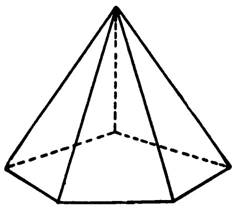


Fig. 50. Pyramid.

A *sphere* is a solid every part of whose surface is equidistant from a point within, called the centre.

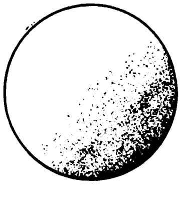


Fig. 51. Sphere.

An *ellipse* is a plane curve such that the sums of the distances of every point in its periphery from two fixed points, called the foci, is a constant.

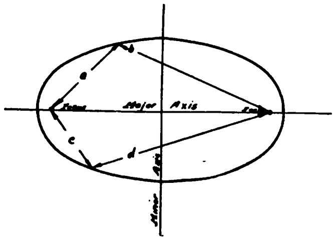


Fig. 52. Ellipse.

A *helix* is a curve generated by a point which moves along the surface of a cylinder in such a way that a constant ratio is maintained between the measure of its rotation and ascent; that is to say, for example, that for every complete turn about the cylinder the point travels an equal distance along the cylinder parallel to its axis, and for every fractional turn, it moves a corresponding fraction parallel to the axis. The screw-thread and the spiral staircase are examples of the application of this curve.

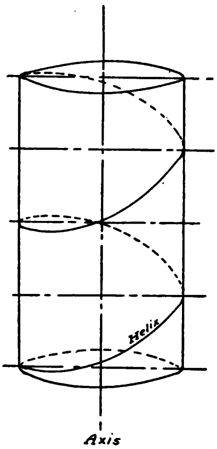
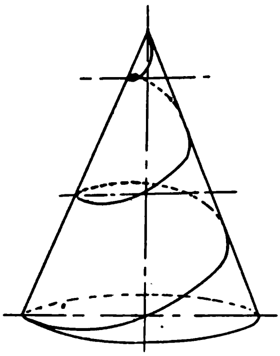


Fig. 53.

When a point moves along the surface of a cone in this manner a *conical helix* is generated. In nature we



Axis.

Fig. 54. Conical Helix.

have manifestations which are very closely related to this type of helix in the shell of the gastropods or snails and the helix of the ear. We see it also in the whirl of an air-current deflected by the surface of a building or other obstruction, in the water-spout, etc. Surfaces or volumes coiled in this manner might be described as of conico-helicoidal form.

Polarization and Equilibration[1]

Polarization is necessary for tone-making, because it defines the pathway of voice.

The author has discovered that the air-cyclones in voice are centralized or "focussed," as it were, at a point before they are emitted at the mouth. This new phenomenon is best described by the word "polarization." It must be understood that voice, *not sound*, is polarized. Neither must this be confused with polarity, for the voice possesses polarity, inasmuch as the mechanism producing it is bipolar. *The voice is therefore polarized.*

[1]See Glossary.

Everything in nature shows the polarizing tendency. The earth is polarized, the north and south poles representing positive and negative forces, with the equator as the balancing power of equilibrium. Every individual may be likened to a miniature planet. The two poles of the human body are represented, first, by the region in the brain dominated by the activities of the pineal gland and held in balance and equilibrium by the pituitary body; this region is separated from the real vocal parts by the floor of the skull, and is the great inspirational and intuitional pole that dominates the mental activities of the vocal effort in their relation with spiritual forces, and corresponds with its sexual analogue below the viscus, held in equilibrium by the solar plexus representing the physical relationship according to the laws of cosmos. Secondly, by the cavity containing the genitals, with the epigastrium or solar plexus as the balancing power. Everything in nature is dual; there is always a right and a left, or positive and negative polarity of being. The positive or right side represents the stronger, while the negative or left is the weaker. This accounts for the fact that the organs on the right side of the body are placed lower and are more powerful than those of the left side. Everything is polarized. Yet there are scientists who deny that polarization of vocal sound exists, and who cannot even see the analogy of polarization of voice and light. If a Nicol's prism creates a straight pathway for crooked light-rays to pass through different media, what does a phone do to sound when it carries the sound through such different media as air, water and stone-wall to the top of a house as well as the bottom, and allows the voice to be tapped at innumerable points?

Similarly, if a beam of light is passed through a crystal of Iceland spar it is divided into two distinct rays known as the ordinary and the extraordinary, or polarized, ray. The light-waves of these two beams are at right angles to each other.

In ordinary rays of light, the light travels in various different transverse directions, and is called heterogeneous. This is best shown by a section of a light-ray. When the

light-waves are all in the same direction, the light is said to have been polarized.

To simplify, assume several vertical stakes in the ground just far enough apart to allow a ring to pass between them. Try to roll rings through them. Only the rings vertical to the ground will pass through. The rings rolled to the stakes correspond to the heterogeneous light, while those which pass through the stakes correspond to the polarized or extraordinary ray.

In other words, as a ray of light, so a thrust of the vocal sound. Besides the main polarization of the body, there are lesser polarizations in all its component parts. Each of the five vocal autonomies contains its poles and balancing factor; even the nerve-cells answer to the same law.

When every part of the vocal mechanism is operating coördinately and automatically and when each of the five autonomies acts in perfect correlation, then, and only then, can perfect tone be made.

One of the greatest poles of domination of activity, in the human voice, is at the region of the base of the tongue, from the middle portion of the tongue to the epiglottis, which is governed and controlled by this posterior part of the tongue; or, to grasp the subject by autonomies, the posterior pyramid of the tongue extends from where the mylo-hyoid muscle is attached, at the side of the middle of the tongue, to the hyoid bone, then on to the epiglottis; the hypothenuse of the basic right-angled triangle of this pyramid extending from the lateral union of the mylo-hyoid with the tongue to the epiglottis.

This pyramid is of prime importance, not only in its connection with the acts of swallowing and the many and various acts of digestion, showing as it does the intimate relations existing between many bodily functions, but also in the polarizing, and equilibrated control of voice-structure. Or, in other words, we have a double pyramid functionating; a coördinating larynx with a correlating pharynx, mouth and dome. Were it absent from the human voice-mechanism, there would be no sonoric or vocalic units, nor could the three great hollow pyramids of voice-structure

be possible; no intensification of glottal emitted tone; no thrill of emotion centralized, amplified and intensified at the glottis opening, by means of the ventricle and its appendix. At this part of the tongue there is created, by pressing down the epiglottis, the first resonator, an overtone space, and the first control and intensification, also compression of the ventricle, the hollow pyramidal space between the true and false cords and the appendix, seldom spoken of or alluded to in voice matters. They are all organs, which are controlled by the relationship of the epiglottis to the hyoid, in the order of the one-two-three movement of the vocal box, or where solidity, weight and density of the static solid vocal cord can best mould energy into voice. By this movement is meant, first, the coördinated action to establish momentum of fundamental tone at the true cord or band; second, the action of the false vocal cord or overtone-producer; third, the action of the epiglottis as the regulator of form or quality, or the cover of the immovable sound-conductor as resonator. All these organs are coplaners moving in the same plane to produce, by their united individual and conjoined action, the sonoric unit or first vocal sound-tone-form and resonance space.

The vocal autonomies of pyramidal shape have been anatomically outlined previously. Between the sonoric and vocalic units lies the resonance and voice-actuating pyramid. From here the sound may be deflected up to the choanæ onto the posterior tips of the turbinated bones. The sound cyclone strikes the posterior tips of these bones and creates by its contact an intensification of vibratory sound at these points, and, in accordance with the physical laws of sound, is carried, by deflection refined by diffraction and sympathetic transmission through, and transmutation around another body, through the nostrils. This first pyramid is the great controlling factor, not only opening up the air-passages, but also controlling the action of the pyramids above. Air sent up from the sonoric unit may be deflected up to the choanæ and turbinated bones, or may be sent out through the vocalic unit, by the adjustment of this pyramid.

Without this pyramid, voice would be sent from the sonoric unit up to the pharyngeal pouch or dome, only to be deflected back. However, since this pyramid brings into coördination the palate and in correlation all the other portions of the tongue and mouth, the seeming difficulties of explanation in this matter, are overcome. The palate divides the voice-current into two streams, one going through the vocalic unit, the other deflected to the posterior tips of either inferior, middle or superior turbinated bones to form the third, fourth, fifth, sixth and seventh overtone spaces respectively. It is the action of the apex or pole of this pyramid that plays such an important part in voice-production.

If these sound-pyramids were not placed at a common pole, as they are in nature, polarization could be effected only with great difficulty, if at all; but with the common pole it is accomplished automatically.

The hollow-spaced air-pyramids of the resonance-unit of tone in its passage downward, after being deflected by the choanæ, joins the deflected and refracted sonoric hollow pyramid of air in mutual polarization. Thus we have the greatest potentiality of voice at the palatal orifice of the mouth, where it is combined into graduating divergent sound-waves, with all the component parts of pyramido-prismo-conico-helico-cuspoidal-spherical relationship.

The pyramids of the oral cavity or Vocalic Unit exist in a horizontal position, and are the structures which control the amplitude of the voice; while the nasal or Resonantic Unit, which is the only immovable pyramid, occupies a vertical plane and makes possible the intensity and resonance of the vocal tone.

That portion or pyramid anterior to the turbinate bones is, then, the smallest pyramid of the vocal instrument, and always remains the same, as it is a fixed pyramid.

The vocal pyramid giving rise to the amplitude is variable, as its bony structure is under muscular control and contains muscular units incorporated in the tongue and soft palate.

As the vocal cords are adjusted for a certain tone and the pneumatic sets them in vibration by its current of

air, we have, with the jaw and tongue in a fixed position, a tone of definite amplitude and intensity. Now, as any of the factors are changed in the least way, so too will the amplitude, intensity and quality change to suit the new conditions.

The pyramid of negative polarity is situated at the lower end of the abdomen, from the demarcation made by the lesser omentum, and embraces bladder, genitals, everything, to the posterior, inferior plane or sphincter ani. Its function is to control and dispose of the results of the activities, of the solid and liquid elements of the body and govern the polarity of all these functions. which are subject to the same law of activation of static force with its own sevenfold Kinetic Pathway of forces (see p. 167), as shown by the order and arrangement of the organs contained in its boundaries. These are specially separated from the sound-producing functions. The dynamic pyramid which is above, is controlled and enveloped exclusively by the greater omentum. This pyramid of negative polarity has as its analogue in the head the pineal body, with whose assistance the brain is supplied by the acts or functions of cerebrum and cerebellum separately; thus these organs, contained in both autonomies or kinetic centres, govern the very impulse, both physical and mental, in polarity, or equilibrium, in the pineal and pituitary bodies, in combination with the physiognomic senses, as does the lesser omental pyramid, in caring for the result of the processes of digestion, nutrition, defecation, and sexation.

It is fitting here to make some reference to the polarization necessary for vowels and consonants. Let us take radium as an illustration. We find that the initial, kinetic force manifested through this precious substance has three rays, the alpha, beta and gamma rays, all of which are polarized and radiate in the same line. The alpha and beta may be deviated and bent back from their path of reflection and refraction by means of electro-magnetic force; but the gamma cannot. This means that the polarization of the gamma ray is stronger than that of the others. Now, it is found that if one can break up this force by interposing various shutters, so as to

develop a certain momentum with interruptions, it is no longer deadly in its action upon human tissues. It is also found that the alpha and beta rays are not harmful when deflected.

The vowel is like the gamma ray, and this is quite in accord with the latest and best scientific reasoning on the phenomena of voice. The polarized vowel-sound proceeds directly up to the dome, although altered in its course by the epiglottis, and never desists from turning to the right, which furnishes it the centrifugal combination which makes it the centre of the voice-stream. This is what furnishes the first or sonoric sound as it strikes the epiglottis; and it is what supplies the vocalic or audible sound as it passes through the mouth.

The centrifugal stream is carried up to the delta, or palate, which divides it into a stream through the mouth and another through the back of the nose; with it is the companion stream or centripetal current which follows and gives us consonant-forming power coördinated by the palate and tongue, but correlated by the lips and soft palate. The position of these organs controls the air-stream, but the centrifugal stream can be thrown up through the nose sympathetically and can also be separated.

Having considered the matter of the pyramids and the polarization concerned with vowels and consonants, let us take up for investigation the vocal stream and its relationship.

First, the one-two-three of the voice, (that is, the co-planar movement of voice,) begins where the dynamic and pneumatic portion of the voice is fully prepared and perfected for the momentic part of the voice by the primary physical forces of solidity, weight and density, acted upon by the dynamic and pneumatic units, in the solid formed cricoid cartilage. Within its hollow cavity this force is ready to be discharged upon the two vocal cords. If we look upon the vocal cords from above, we find that they are the exact replica of a double polarized brain-cell, and each cord, like the brain-cell, is subject to two polarizations. The arytenoid cartilages, acting together, represent the positive pole, with the ligament binding the cartilage of

Santorini to the pharynx, the anchorage of this pole. The negative pole is at the thyroid end of the cords, and can be demonstrated by singing a tone on inspiration.

If we observe the same law as governs the brain-cell, we shall also find that when two cords are brought together to produce a sound, the right cord polarization (positive) is superior in its directing influence to the left vocal cord, leaving the discharge of the momentum directed toward the right. This force is not disturbed in momentum (except by the resiliency of the crico-thyroid membrane) until it reaches the epiglottis, which then is put into position to create sonority.

This gives us another point of polarization, which we shall have to call the sonoric unit of voice, because it catches the momentum made by the vocal cords and compels it to assume a certain sound-form or quality, therefore it is a sound-tone-form and is formed at the epiglottis, which polarizes it at this point. We see this special point emphasized in the shape of the upper edge or border of the thyroid cartilage, and also in the triple curve of the epiglottis as it covers the thyroid in carrying out the design and pattern of nature.

The direction of this polarized sound or voice-stream is now in a curved line upwards; it meets the delta or palate, which divides or cleaves it into the sound, which passes back of the uvula; here it is polarized by the uvula (and palate also) into resonance as it enters the dome, and is reflected back by it as resonance with inter-polarization between the soft (regulating) palate and the dome itself with its choanæ, establishing the peculiar quality and character of tone called, by some authors, resonance. This is the sound assumed by many singers as pure voice and its correct production. In reality it is neither resonance nor the correct polarized pathway of voice, therefore cannot be correct voice-emission. It lacks the sympathetic vibrating sound of the turbinated bones; hence, I call it the choanæ tone-production—affected by many sopranos as the correct method of singing. Also resorted to by worn out sopranos who have lost the power to produce that scintillating quality of tone that I liken to the radiating

sparkle from the diamond when it catches the rays of the sun.

The tongue, the ever-present officer of polarity and direction, enters into this action of polarization of resonance, because it is attached to the palate and is necessary to polarize the sound for the mouth, the oral or vocalic unit. This sound is reflected back by the mouth or buccal cavity, with interchanged poles, at the arch of the eye-teeth, but not by the tongue. The mandible or lower jaw does not have so much to do with the polarization from the standpoint of this unit, except as a pole of sympathetic resonance, because it regulates the buccal muscles, which form the resonating cavity, and helps control the arching of the tongue, which can polarize sound either at the back or front of the mouth and accommodate and control polarization of both larynx and pharyngeal dome in an at-onement that borders on the marvellous.

It will be observed that we have similar polarizations, interchanging, in both the resonantic unit and the vocalic unit; in other words, we have had resonance, reflection and refraction (detonations deflected, transmitted or transmuted) established in all, and all polarized, thoroughly in accordance with the laws that govern a brain-cell, a blood-cell, a lung-cell or a muscle-cell; and the discharge of force from these different tissue-cells has been carried out in the same manner, namely, by the way of the hypothenuse.

There is another phase of polarization common to both in the dome. In the front part are the two funnels or apertures already mentioned, called choanæ. It will be easily seen that, as the pyramidal cyclone of resonance travels back of the dome, it meets with no resistance where the two funnels or choanæ are; but on each side project the pointed tips of the turbinated bones, presented at the very mouth of the choanæ as it opens into the dome. As the vocal pyramidal cyclone previously described strikes each one of these turbinated bone tips (if the bones are normal at the posterior angle) it intensifies the resonance.

The law of this intensity of resonance would be as the discharge of the momentum, which is represented by the posterior linear portion of this pyramid of the turbinates, plus their lower border, which represents the amplitude of this resonance caused by the oncoming cyclone which was thus divided into sympathetic force transmitted through the turbinated bone and the waves transmuted about it. In consequence of this created intensification of all forces concerned, there would develop through momentum and amplitude of the vocal vibration of the discharge of this sound, real physical energy of dangerous proportions, that would harm the tissues involved, as is seen in certain cases of diseased nasal bone, when vibrations are induced by a tuning-fork placed upon the teeth, which causes intense pain as the dead bone vibrates to the fork in the healthy marginal tissue about the diseased bone. To obviate this and also to prolong and carry out the proper quality of the tone to a perfect finish without deadening it, hollow aerial spaces are created at these points in the bones of the skull, called sinuses, to absorb the shock and take care of various other phenomena caused by voice-production of this physical momentum. Other fine comminutions of sound which are not absorbed in the impact and are necessary to the correct balance, or equilibrium and polarization of tone, are carried out through the nose, and through the apertures underneath these sinuses; each pyramidal sinus cutting out and using its own tonal vibration to assist the forces of sound. They are collected in the vestibule of the nose, and thence join the stream of voice coming from the mouth, carrying out the true idea of regulation and plan of forces of the "overshot wheel" of resonance of the nose, in direct proportion as it relates to the mouth, in its relationship with the overshot wheel of voice, or with the Adam's apple, which is the only true regulating angle for momentum and pitch at the vocal cords.

Having described in detail this phenomenon throughout the nose, we may say that the same phenomenon is indicated and carried out with the teeth and lower jaw, in coördination and correlation by the vocal stream, which has been directed by the tongue through the mouth.

Polarization is carried out directly and indirectly through the entire voice by the tongue, which is the great polarizing director.

The understanding of polarization as applied to voice, enables the scientific teaching of voice, in either speech or song, to begin with units and the standardization of fundamentals, and advance little by little, wisely eradicating or correcting at the same time the errors by former experiments, until the course is completed.

The importance of this understanding will be seen when it is realized that, for polarization of voice, every autonomy must be balanced in equilibrium, and without this balance there can be no true and perfect production of voice. If a tonsil, plica, septum, palate, turbinated bone, antrum, sinus, or any tissue concerned in the mechanism or in paralysis or akinesis; intercurrent adventitious or even circumstantial disease of tissues, concerned in voice-production, be removed or changed without regard to phonetic values, the sympathetic conduction is lost; this destroys the balance and beauty of the voice, as stated above. The same applies to the removal of a turbinated bone without cause, which means loss of deflected resonance, for various tones. The inferior, middle and superior turbinated bones are the conductors of deflected resonance for the fifth, sixth and seventh overtones, respectively. Thus, if the inferior turbinate be removed on one side, the fifth overtone on that side will be lacking in refracted resonance. The other side, which has the inferior turbinated bone, will possess that deflected resonance of the fifth overtone, so that the sound emitted at the nostrils will be out of balance, and not in harmony, hence will not be a true one. These instances further show the necessity of polarization and balance in equilibrium, for true voice-production.

The voice-units, and autonomies of the human body, as they are called in Vocal Art-Science, are under the will of the trained student or artist. It is a matter of consciousness—perception and sensation. Each has its group of resistant (bony) and elastic (muscular) parts, and is *known as a group* to the singer who has been trained

according to the fundamentally scientific principles of Vocal Art-Science. Strakosch said the Italians believed in training voice by imagination—not muscles—to avoid muscular effort. He really meant *conscious* muscular effort; avoided by Vocal Art-Science training, because groups are trained (as autonomies) in such a way as to *render their action automatic*. Therefore, why not train by *autonomies*, and avoid the physical effort of blending *fundamental overtones*, *partials* and *harmonics?* Train the balanced (grouped) muscles, as autonomies, the imagery of sensation—Imagination or reasoning quality, when the apperception will balance in the relationship of Power, Resonance, and Pitch—as perception of consciousness and sensation.

It is a fact acknowledged the world over that physicians and singing-teachers have much to learn of the human voice and its operation. For instance, there are about seventy different methods of removing tonsils. The fact that there has not hitherto been a standard operation established, argues a gross lack of knowledge among the so-called throat specialists. Many great surgeons admit that the world is in need of some definite standardization of this operation; and with this must be formulated a series of after-treatments suited to each individual case. In some cases of tonsil-removal the ignorance is so lamentable that the surgeon removes by tonsillotomy a large part of the alphabet of the patient. That is to say, the improper removal causes the voice to lose all or most of its resonance and sympathetic conduction, and, worst of all, its polarization and balance or equilibrium. If a tonsil is thus removed, the polarization of that side is lost, which in turn means that the adjustment of perfect balance no longer exists; and of course, as soon as balance goes, the beauty of the voice goes with it. For without a tonsil and its capsule or a plica of the same, there is little chance for any sympathetic conduction of vocal sound to other parts of our vocal anatomy. And what is voice without sympathetic conduction, without the proper resonance quality, or without that beauty which makes it so superior to man-made instruments? It is about as

useless, so far as singing-value is concerned, as a water-wheel without paddles in which to catch the water.

This loss of a tonsil, with capsule and plica, according to the usual surgical procedure, should be a cause for worry to singers, for the improper removal of tonsils means not only a lowering of voice-value, but also physical and mental affliction. This being true, Vocal Art-Science, by its standardization of surgical operations rendered necessary by disease of the vocal apparatus, affords a means of not only producing better singers, but also of improving the health of the community in general and preventing further voice destroying operations.

The Board of Health regulates our actions—compelling us to follow certain rules in regard to body cleanliness; and, in our schools, specifies the best bodily position or posture for the child. This is all very proper and right. But, along with these physiological requirements, and of really vastly more importance for the child's advancement, would be a deeper study of the faculties and operations of the MIND. Statistics show that, out of 800,000 children in New York City, 200,000 either stammer, stutter, lisp, mutter or mumble.

From the detailed study of the vocal mechanism and its governing mental faculties, it will be of interest to note how Vocal Art-Science can discriminate between the varieties of speech abnormalities.

First, let us consider the choice of the terms Stammering and Stuttering as means in themselves of differentiating these two types of vocal anomalies. It will be seen in the spelling, first of all, that a decidedly different mechanism comes into play in Stuttering from that in Stammering. Spell "S-t-u-t-t;" the tongue against the teeth tends to produce an exciting effect extending even to the diaphragm, giving a sensation of physical effort. On the other hand, as we spell "S-t-a-m-m-e-r," the "M-M" immediately concentrates your attention on the lips, i. e., the word to be expressed is completely formed and about to be completed by the lips, but, owing to a lack of proper mental adjustment, the muscles are not properly brought into balance through the nervous mechanism, and an improper correlation results.

In the case of stuttering the mental control necessary for perfect vocalization is efficient, but the proper adjusting powers of the muscular autonomies necessary for verbal expression are lacking. The subject has a clear conception of what he wants to say, but at the moment he endeavors to express himself finds that the automatic adjustment of the muscles has failed to respond properly.

Here the defect lies in a physical failure of muscular action which normally takes place automatically, upon the formation of a mental picture of the verbal expression. We all hesitate and stutter over words new and difficult to pronounce, because we are unable to adjust our muscular apparatus quickly enough. This restraint disappears after a few trials.

Thus it is that the deficiency to be considered in the case of stuttering exists in the lack of proper muscular coördination of some definite set of muscles, each case varying according to the series of muscular autonomies affected. Hence, by formulating a series of syllables, words and phrases, these muscles can be toned up to their normal reaction.

The pyramids and muscles of the face are shown to have a physical connection with all the physiognomic senses. Nature, to make this correlation possible, provides muscles which reach from lip to nose, from lip to eye, and from lip to ear.

In stammering we recognize the lack of mental or governing control. Here the word to be spoken has given rise to a mental picture, and the automatic adjustment of the muscles necessary for that special word has taken place; but in this case the brain fails to send down the stimuli in the proper sequence, and the coördinate action of the muscles is retarded.

It is to be understood that the foregoing statements are offered to demonstrate, not the pathology of the conditions themselves, but the manner in which Vocal Art-Science formulates its diagnostic principles from the living, breathing being, or life in its concrete form.

We know that the development of intelligence results from the definite modifications upon the framework of

fundamental functions, in the central nervous system, produced by *perfecting the sense-organs*, and *by establishing paths of association between them.* We know that the brain-power depends, chiefly, upon the *complexity of these associations.* We also know that *lack of development* in one part of the brain *weakens the whole structure.*

Our efforts, then, should be to establish, in the brain of the child, the greatest possible number of functions, and of associative reactions between them.

No true man of science thinks that things "happen." Every result must have an antecedent cause; and this cause, in turn, *may be the result of another cause.* Back of the created is the Creator. And this applies just as much to the Universe and the Systems that compose it as it does to an engine and its human designer.

It is apropos at this point to bring out the relationship of the auditory mechanism to vocal perfection.

As yet no mechanical device has been perfected to take the place of the human ear in voice standardization. Through the application of Vocal Art-Science methods, the tympanum or eardrum has been found to be cuspoidal instead of disk-shaped, thus proving the inefficiency of a disk-like (flat) diaphragm in reproducing pure tones and overtones. It is hoped that with this added factor much new apparatus will be constructed which will fill this long cherished desire.

At present we must rely upon methods of auditory education and perception to establish methods of standardization.

The cuspoid alluded to in pyramido-prismo-conico-helico-cuspoidal-spherical relationship is the true cuspoid of the ear-drum. Cuspoid is the egg-shaped globule representing the form of beginning of a sequence of segmentations of a new voice structure. It is on the same lines of kinetic construction as has been used in making the sound-tone-form, from which it arose. This occurs at the point at which two curves terminate tangentially. It is the curve made by the two planes on the inner side of the ear-drum (tympanum), one of which is the plane governed by the malleus and the other the plane governed by the incus in

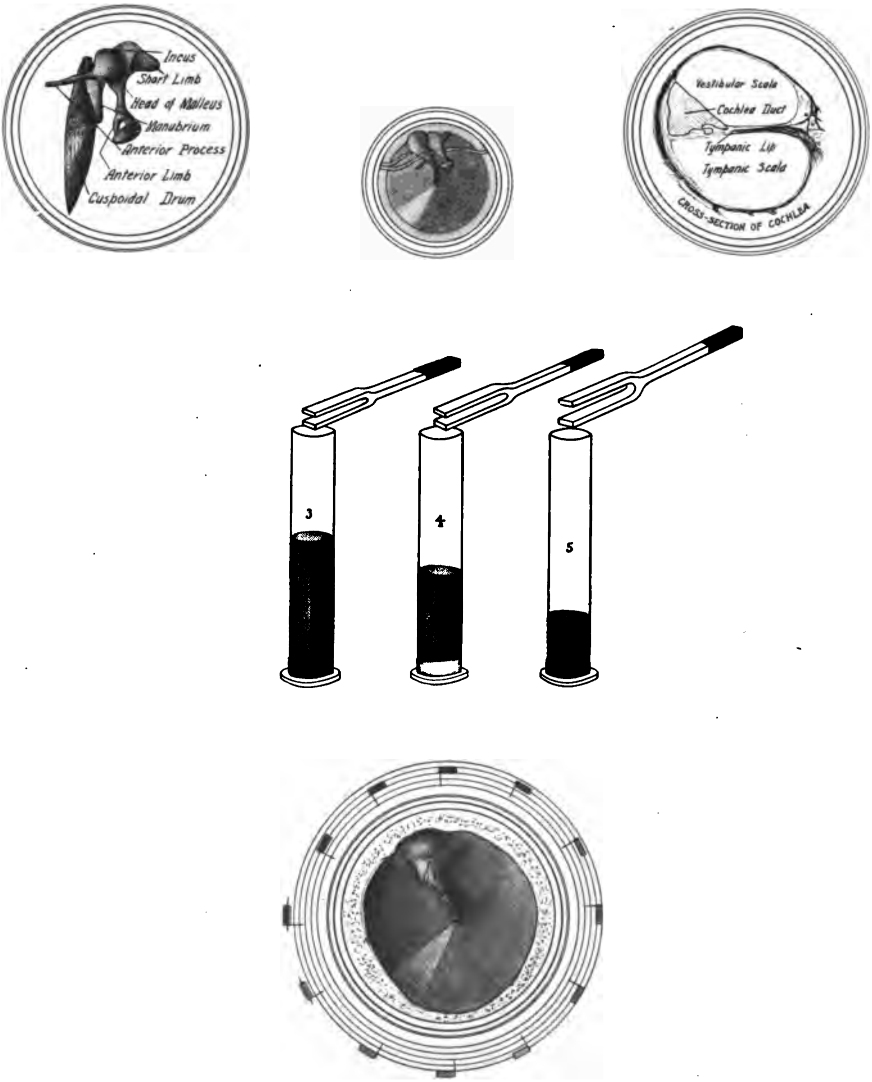


Fig. 55. Kinetic Receiver of Vocal Impulses upon the Human Ear.
(William F. Fraetas.)

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their toggle-joint arrangement, that creates a seemingly flat surface or slightly oblique cone. From the apex of this eccentric cup-shaped membrane the auditory body is created. It is cuspoidal in its evolution and has distinct effects in final determination of polarization of sound, of the human voice. This cuspoid then leads to a sound-tone-form that causes voice to progress *en train*, not *en masse*, without pitch-period, with perfect balance, equilibrium and polarization. The model of the cuspoid is obtained by laying out a circle of a convenient radius. The radius (A B) is divided

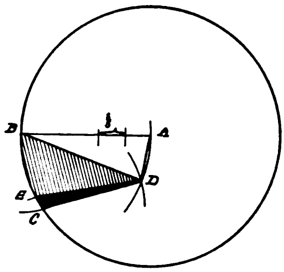


Fig. 56.

into 5 equal parts. From B lay off B C 3/5 of A B on the circumference. From B swing the arc B C. From C swing an arc whose radius = 4/5 A B so that it cuts arc A D. Then D B C is a 3, 4, 5 right triangle. Lay off E C from C on B C equal to 1/6 of B C, triangle B E D. Cut on line A D. Bring B and C together so side B D touches side D C. This will form the true cuspoid.

The above material has been incorporated to demonstrate the many possibilities of advancement to be achieved, as well as the innumerable obstacles overcome and explained, by Vocal Art-Science.

CHAPTER XVI

Vocal Teacher and Pupil

Voice, in artistic singing, calls for complete control of the vocal instrument, combined with the entire resources of metaphysical art.

It would seem that our chapter on vocal pathology should, logically, be followed by one on vocal hygiene; but as this subject is inseparable from that of the relation between vocal teacher and pupil, I present it for consideration in the more direct, the more personal form.

No panacea for vocal disorders.

Hygeia means the preservation and restoration of health. Let us state at the outset that there is no panacea for vocal disorders, nor any specific régime which ensures vocal hygiene. The preservation of a voice under proper control, is secured by exercise, air, diet, clothing, rest, recreation, cleanliness, and morality, all regulated to the creature's needs according to the laws of life.

Health necessary to voice.

Without health, without soundness in the whole organism no less than in its special voice-producing mechanism, there can be no perfection in the art of speech and song. And conversely, under normal conditions, soundness in the whole organism no less than in its special voice-producing parts, should result from the exercise of an art that involves the entire being, physical and psychical, sonatic and spiritual.

Singing based on science.

Singing, like all other acts, is based on science according to natural law. Artistic singing is science applied. But "before there can be applied science, there must be science to apply." Yet how many of the innumerable teachers and writers who put themselves on record as authorities can measure up to this obvious and elementary requirement?

Expert testimony on lack of trustworthy vocal teachers.

Listen to this testimony of eminent specialists along these lines: "What becomes of all the vocal prodigies?" asks Dr. Horsford. "It is truly pathetic to note the amount of beautiful material failing, the world over, for want of knowledge and skill."

"It produces an indescribably miserable feeling in mind," says Dr. Wesley Mills, "to know that the methods pursued by a young person of sound organs and naturally good voice must inevitably lead to vocal ruin." Also he adds that were he engaged in active practice he would conceive it his duty to prescribe change not only of method, but of teacher, in such cases.

"A number of patients, voice-users," says Dr. Payson Clark, "owe soreness of throat or hoarseness entirely to improper use of the voice. My difficulty has been to find teachers able to show the proper use of the organ."

"The number of singers who come to us for relief and health is very great, singers and speakers whose whole career is in peril," attests Dr. D. Bryson Delavan, "and it is very disappointing to believe that we have found teachers properly qualified to aid our patients, only to find the results no better, if not worse, than before."

"Ignorance of method," Mr. W. J. Henderson sums up the matter, "and incorrect methods; these are the prolific causes of voice failure."

Number of books on vocal art.

Yet in the New York Public Library are works by over seventy authors, each of whom claims to be the ultimate authority on voice-culture. One of these whose book enjoys wide popularity recently said that "off pitch" was the only fault among singers. When quizzed on resonance, volume, style, and a few other universally conceded attributes of artistry, he stated that pitch included all these—everything. Now, while pitch is essential, consider the effect if a singer did nothing but "pitch his voice" before an audience. Surely, the man's definition was at fault, not his understanding. Yet can he be taken seriously as an authority?

Example of ignorance in well-known writer.

In 1912, according to Pierre Keys, two and a half million dollars were spent in and about New York on voice-culture. Yet what of the harvest? Where, in numbers proportionate to this enormous expenditure, are the reliable singers on whom one may invariably depend for good tone, correctly balanced power, resonance and pitch, with clear enunciation? Where are the speakers in pulpit

Lack of standards and models.

and on public lecture platform who know even the rudiments of the mechanics of their profession? What are the natural standards? Where the exemplars whom we may bid our children copy? Beautiful voices are not uncommon in this country, yet both in speech and song these appear to disadvantage from imitating wrong methods, if not from cultivating them.

Governing choice of teachers.

When one reflects and thinks of the great personal and family sacrifices often made to obtain the needful funds for voice-instruction; together with the hazard of a life-career, one is amazed at the lightness with which persons, even eliminating the conscious charlatans, announce themselves as professors of the vocal art. Only less amazing is it to reflect on the irresponsibility which generally governs the choice of a director. Often a popular pianist is picked out, as if the human instrument offered no qualities but those to be found in implastic metal, wood and ivory. Too often the church-organist and choirmaster is favored without the slightest inquiry into his fitness to give individual instruction. Vogue, fashion, an agreeable personality, all these are common factors in the selection of a vocal teacher. True, any and all of these may be admissible in teachers of voice, provided they also are scientific and artistic to the last degree, but this latter must be positively established as a definite requirement, and not as a possible accompaniment to other forms of preëminence. In effect, precise knowledge of the vocal instrument, together with precise knowledge of the principles on which Vocal Art-Science rests, is essential in its teachers. Since

All voice physiological.

all proper use of voice is physiological, all methods productive of poor results artistically, are therefore physiologically unsound, and assuming intelligent coöperation on the part of the pupil, must be set down to the

Need of certified teachers.

teacher's ignorance. The day will come, and may it be not far distant, when people will no more entrust their vocal organs to the care of an uncertified instructor than they would call in the plumber to tune the piano, or engage a piano-tuner as chauffeur.

Speech and song

From a certain group of teachers, so-called, we hear much about the undesirability of voice-technique.

"Breathe naturally!" cry these. "Speak naturally! Sing naturally!" Exactly what they mean it would be hard to say. Breathing, as we know, is an automatic act in the natural process of merely keeping alive. Breath-control in speech and song is an acquired art. People rarely speak or sing naturally. Speech and song are developments of natural forces, never achieved except by secondary process, through imitation and association. The great object of Vocal Art-Science is to establish a standard, to render automatic the habit of perfect speech and song. **second nature.**

To train voices that have normal adjustment of anatomical parts, unspoiled by faulty methods, that is a minor detail of what we seek to accomplish, in the present. To take the failures and semi-failures already in the world, the ears deaf to musical requirements, the crippled voices, restoring these to normal functioning, that is the heavier burden we assume. **To heal crippled voices a chief task of Vocal Art-Science.**

The ideal teacher might conceivably combine in himself physiologist and artist, laryngologist and musician. For the present we insist on his being physiologist, artist and musician, and advise with all the emphasis of which we are capable his frequent coöperation, in general sessions at least, with the laryngologist, and the medical specialists of voice. Auto-laryngology is to be discouraged in a student. Nothing is worse than to induce super-consciousness in an organ. Singers must learn to sing, not alone naturally, but as if it were natural to them to express thought and emotion in this way, as if by second nature: A correct automaton. **The ideal teacher.** **Need of coöperation.**

In understanding the training of a pupil the voice-teacher should first be assured of physical soundness in his subject. Careers have frequently been ruined, not to speak of voices, by the necessity of some operation, which should have been attended to with allowance for complete recuperation before training began. Also it is to be remembered that certain types of voice present features that are the results of some abnormal condition in the vocal apparatus or elsewhere. Exercising the voice-organ under such circumstances serves only to accentuate its faults, to fix its habits. A correct diagnosis should be **First duty of teacher to ascertain physical condition of pupil.**

formulated and the trouble removed before any attempt at routine work is made. In this matter the teacher is warned not to trust to his ear alone, as this, however infallible in normal cases, is no guide for the exceptional. There are vocal faults, and many curable by vocal methods alone; also there are not a few that are the province of the medical specialist, especially when abnormality of any kind exists. It should be an article of faith with a teacher of voice not only to be assured generally of a pupil's well-being, but to have this positively guaranteed by competent medical authority before accepting the responsibility of a would-be artist's career, not to say a fellow-worker's livelihood.

Knowledge of machine the duty of teachers.

Let the teacher of Vocal Art-Science, then, understand that it is impossible to dissociate the artistic from the physical. He must know by heart the machine as it should be, inside and out, before advertising his qualifications to direct it. After that, every pupil must be considered individually, to ascertain what conformities to type and what divergencies from it this special machine presents, in order that time and money may be well invested on both sides; that no steps may be taken at random; that everything from first to last may be done rightly.

Specific instruction to vocal teachers.

Specifically, such a teacher, once satisfied that the subject in hand is in condition to respond to all legitimate demands upon its powers, is advised to instill into the pupil the principles to procure freedom of action by preliminary —specially individualized—exercises. In the well-trained voice, the glottic folds are poised by air-pressure, or, in other words, become vocally vitalized; this balances breath so as to allow muscular activity full sway. However, we now are speaking of raw material, or of those trained faultily. The tendency even with singers of experience is to constrict spaces, to obstruct the vocal channel, for the simple reason that it is human nature to want to take some active part, to do something positive when a desired end is to be achieved, and never to let well enough alone. In a word, they interfere.

Interference.

So great is this tendency, that interference may be termed the arch-foe of good vocalism, nor is this surprising

when we recall that Vocal Art-Science rests on proper muscular control.

There are no halfway measures about this. People either use their muscles according to correct automatic procedure, or they use them wrongly. If the latter, they must unlearn by tedious processes before attempting one forward step.

The master's ear the only test.

With the master's ear as criterion, and with progress corroborated by photography, vocometer, or whatever appliances science can devise, the entire muscular system must be prepared, loosened and rendered supple, and the intrinsic muscles unhampered by external constriction.

The muscles of the throat have a typical natural quality. When they are deranged, they produce false sounds readily detected by an expert ear.

Interference with cord-stretching.

The principal muscles which by contraction affect the voice are those of soft palate, the pharyngeals, muscles of tongue and chin, fibres of ventricular bands, and those surrounding the ventricles; and, above all, all extrinsic muscles attached directly or indirectly to the thyroid cartilage and likewise the adjustments of uvula, lips, palate, tongue and vocal cords. If by undue muscular contraction the thyroid cartilage is pulled upwards and forwards away from the cricoid, the little arytenoids will be fixed so firmly that the vocal bands will be unable to rotate and the necessary equilibration for proper pitch is impossible. Without this rotation we lose two factors that condition pitch, namely, by the lessening in length and weight of the vibrating folds, thus throwing the entire burden on the third factor which increases tension. Not only does this mean undue strain on vocal muscles and folds for the high tones, with forced expenditure of breath to combat the interference, but also fewer segmentations of the cords, with consequent depreciation of quality.

Special interferences.

Interference from the muscles of the ventricular bands and ventricles can best be understood by referring to the office of these parts. The superior laryngeal bands, it will be recalled, have no share in inspiratory phonation; they simply, by their automatic closure, guard the larynx during the act of swallowing. The ventricles afford a space in which

the vocal folds may vibrate with freedom, and also lubricate them from the mucous glands with which they are equipped. When muscular contraction takes place, the walls are drawn inward upon the vocal cords by the ventricular bands, the height of the air-waves is cut down at the source, and loss of power results, together with depreciation of quality and a certain unmistakable roughness of tone. Any contraction of the pharyngeal constrictors also narrows this space, pulling down the back of the tongue so as to force the epiglottis backward and downward. Contraction of the palato-pharyngeus makes tone hollow.

Tongue interference.

A grooved or lowered tongue gives tone a hollow sound; an uplifted tongue muffles tone; and drawing back the tongue-tip, thereby enlarging it, thickens tone-quality. These interferences are reflected on the palate, which in turn communicates them to the vocal folds, resulting in serious disorders.

The jaw, being a hinge-joint, should work up and down in phonation. If allowed to slip back, to protrude, or work laterally, it disturbs the equilibrium of both larynx-holders and fold-stretchers, and overworks the sterno-cleido-mastoids, which are head-holders and conductors of sympathetic vocal vibrations. This, a common fault, makes the tone short of range and shrill.

Chin interference.

If the mylo-hyoid, which forms the floor of the mouth, overworks, the chin swells on tone-emission and becomes stiff, bringing the larynx forward and producing a shaky tone with sharpened pitch.

Holding the head stiffly strangles nerves and blood-vessels, and kills all beauty of tone. Quality, it will be noted, is always first to go.

Soft palatal interference.

A pernicious interference with resonance, and correspondingly with carrying power, comes from the soft palate. Drawn upward and backward against the pharyngeal wall it shuts off the superior resonating chamber, destroying the four upper partials, and leaving the fundamental weak and poor owing to insufficient area for amplification. This is the only interference that can be ascertained otherwise than by the ear. If by closing nostrils with thumb and forefinger in singing a tone, the tone-quality does not change,

then one has a true nasal resonance. If a change is felt or heard, then something is wrong and nasality is the result, not nasal resonance. No fault is so common as this, even great singers being rarely exempt therefrom.

Deficiency or excess in resonance are signs of imperfect balance at the vocal folds, or the vibrations are prevented free access to the cavities above.

Ministerial sore-throat. High pitch. Ministerial sore-throat means ministerial ignorance of the need to relax the extrinsic muscles. These muscles should be enumerated among the faithful servants exempted from labor on the seventh day, and indeed all others. The harsh tone and the unnatural high pitch heard in public speaking, mean public speakers' ignorance of the first principles governing the mechanism of the instrument of their profession.

Cavity shaping. This process of muscle-loosening, and changing of the cavities, demands minute watching and great care. Not till all muscles are under full control, though this be involuntary and unconscious, can the pupil change the hollow spaces in their proportions, so as to add half-steps, higher or lower, with free emission. By decreasing the area of muscular action in these combinations, the teacher not only extends the range, but also the circumference of the pupil's voice; and the vocal folds, under this improved impulse, are able to intonate to the limit of muscle-action within these hollow spaces.

Sensation experienced by singers on production of perfect tone. Several teachers can add their testimony that many pupils, especially women, when using the head voice or upper octave resonance after acquiring perfect use of these hollow spaces, sometimes experience while singing a buzzing in the head or watering of the eyes. This I attribute to a sympathetic nerve and muscle action between the controls of hollow spaces, laryngeal and pulmonary cavities, with reflex action on nerve-centres and muscles. These sensations, to my mind, will be felt only when the tone produced is perfect, of fine timbre, and full of sympathy; *when, in other words, this one tone suddenly and exactly realizes the fullest intention, perception, and expression of the singer.* The pupils of a voice-builder who can bring about such results have small occasion to consult the

specialist, and are, indeed, generally to be congratulated.

Secretions. The matter of secretions must not escape the teacher. In singers the throat is better constructed than in the average individual, and is relatively dry. When a tenacious secretion interferes with voice the specialist should be consulted.

Cultivation of the ear. As the ear of the master is the criterion and tribunal of vocal excellence, so must pupils learn, by hearing, to judge of their deficiencies. One must discriminate between musical and unmusical sounds, good tone and bad, before going through the muscular movements that produce the desired results. People become accustomed to their own voices, are uncritical of themselves, and self-satisfied. A phonographic reproduction of a voice often amazes and startles the vocalist.

Interesting case of voice-placing by ear and touch. A young man was brought to me for operation, on account of a very high voice that had never undergone the usual change. The first step was by imitating the patient to make him realize, as he had never done before, that he spoke differently from other persons of his age. Then, having told him to hold his larynx down, a lower pitch was muscularly induced with such good results that after a few weeks' training he was able to deliver his class valedictory with much credit, and in normal tone. It is only patients, pupils and singers of the finest type who really thoroughly estimate their own shortcomings.

Inability to vocalize. In the lexicon of teacher and pupil of Vocal Art-Science there is no such word as fail. Singers often complain of inability to sing a pure vowel all the way up the scale. This means either that their method is at fault or that they have not mastered the art of concentrated listening. A good way to hear one's self as others hear us is to close the ears with the fingers and vocalize. The result is like seeing one's self in a looking-glass for the first time.

Voice-using hygienic. Voice-using is hygienic. The vocal organs are by nature strong, the folds themselves being, perhaps, the strongest organs in the body. Proper use adds to their strength, while acting as a body cleanser, vitalizer, and a

builder of tissues. Faulty methods tend to produce venous congestion, to starve tissues and poison them.

Fatigue a symptom.

Fatigue on the pupil's part is sympathetic. It is for the teacher to set the pace, restraining over-enthusiasm, showing how energy should be conserved.

Danger of show-work.

To tax the immature voice, or that of the untrained adult, with show-work, perhaps to please parents and guardians, or the pupils themselves, is a fatuous proceeding. Never force a voice, never put a strain on it, nor any burden that it cannot bear with ease. Song-singing is not a part of preparation, it is a sequence of this, and should not be admitted into the vocal curriculum until the voice-mechanism has been trained to a good balance, so that tone is easily emitted before clear enunciation is assured and song-singing advisable.

Teaching largely psychological.

As we have shown, all teaching worthy of the name is based on physiology. Teaching also is largely psychological. Imitation and imagination as well as precept must be impressed into its service. A hint may be drawn from Professor Bell's way of educating the dumb: Teach the pupil-patient to cultivate sight, as well as ear, and imitate models of vocal perfection. Imitation and example—all singers pay tribute to the benefit derived from these. In her memoirs Mme. Kellogg states that she never heard Adelina Patti without admiring and seeking to reproduce the beautiful, forward production of her voice.

Value of copying.

Pedagogy the scientific meeting-ground.

Abnormal conditions, according to V. A.-S., are for the investigator and specialist with precise physiology on which to base his findings, and psychology to furnish interpretation of the mental attitude. Pedagogy, the teacher's profession, is the meeting-ground for all these, for which reason the need of conference and coöperation, on the part of all who have the welfare of Voice at heart, cannot be too strongly urged. All who seek our aid are potential singers; ours the task, rightly to direct them.

A case of hypnotic voice and its general application.

That all normal beings possess singing-voices only waiting to be liberated would seem to be a tenable hypothesis in view of a remarkable demonstration in my experience of hypnotism. A patient whose voice, tried in the usual manner, showed very low rating, and who was absolutely

without knowledge of music, produced, under the control of a hypnotist, a phonographic record of several selections of noted singers in a fine and finished form. However, this case proves conclusively the dissociation of the mind from the body, thereby adding another definite point for scientific investigation of the facts already established concerning the duality of voice.

When to begin voice-training is a frequent question. My answer is, that the voice should be trained at the age of seven. At this age the first set of teeth have been cast off, and the second set erupted and the permanent set begun. The accessory sinuses are also now in condition to perform their functions and ready for the establishment of the phonetic functions as well.

Coördination, correlation, equilibration, polarization and orientation, especially along the lines of agility and flexibility, are now developed, for from this time forth the pituitary body and the thymus gland will, up to twelve or fourteen years, functionate actively. Two sinuses are positively recognized at birth, namely, the frontal and the maxillary sinuses, and the rest are finally formed at the seventh year.

It would seem, these being the actual facts of anatomical observations of the development of the natural resonating chambers of the voice in the "Normal Human Being," that a system in accord with nature's laws must bring perfection when starting at seven years. At the age of twenty-one the voice will have reached its height and calibre, as it were, in evolution and together with the developing mind the future of the singer is guaranteed without a doubt. He should then be prepared for the brightest prospects of artistic finish, with all embellishments that an intelligent mind can give.

National need of good speech.

Simple vocal exercises, merely for the formation of correct habits, may be attempted. The consensus of opinion now is that during mutation there should be little if any use of voice. This is not necessary; on the contrary, kinetic exercise, vocal and physical, should be used throughout this period to ensure the best possible route to maturity. The chief factor in a young person's education is imitation,

by cultivating taste, calling attention to the best models in speech and song, and by the conscious influence of association, surroundings and atmosphere. It is greatly to be deprecated that good speech is not taught in schools and universities, that the rich are careless in respect to engaging nurses and governesses for their children, and that all, rich and poor alike, do not set higher value on refinement of accent and an agreeable voice.

Teacher as critic.

The throat-specialist, the laryngologist, should himself be somewhat of a musician, most assuredly a student of Vocal Art-Science, otherwise he will not have the greatest knowledge for diagnosis and in effecting a cure. The teacher of Vocal Art-Science need not be a laryngologist, but must be *par excellence* a critic, to analyze voice properly, and also must be endowed with that greatest of factors in producing good results: sympathy. Such a teacher is himself an artist, a sculptor, who from the rough marble shapes that ideal form of beauty, the perfect voice.

What Vocal Art-Science stands for.

Vocal Art-Science stands for the true and beautiful in song. In it are united science, which is the exact knowledge of cause and effect, and the God-given intuition we call Art. Science plods its way by sure steps, every one proved and tested, while Art travels to the final tryst on the magic carpet of the fairy tale. Art is to singing what the body is to the soul. Science keeps watch when Art is sleeping, making ready and perfecting conditions, yet neither is sufficient in itself; together they can hold the world in thrall. It is for the great singer to bring these two into perfect union, and without great teachers great singers cannot be!

To such teachers, then, to the brave of spirit, steady of purpose, earnest of endeavor, these observations on Vocal Art-Science are dedicated.

"Of all voice fashioned by the Great Creator the human ranks supreme, because it is the chief organ of a deathless soul!"

CHAPTER XVII

Vocal Art-Science Exercises

Natural laws prove that there are psychic and psycho-physical emotions. The latter involve the closest possible relationship between the functions of mind and body. Perhaps the most subtle correlation of the physical with the mental, and the most exquisite result of the united action of the mechanism of the body with the sense of art-perception in the brain, is the visualizing by the eye of the ultra-violet ray.

The art-appreciation of the color by the brain, caused by the impulse conveyed thither from the eye, is in turn due to the regular and stated arrangement of the prisms of the eye, which furnishes the kinesis, or sense of motion, of the sunlight to these prisms. Every one knows that he can see violet at the end of the spectrum. But he does not know that he measures this visibleness with the prisms of his eye with the incredible rapidity of 1-90,000,000,000,000th of a second; and that, simultaneously and accurately, the prisms are all automatically measuring the same color in the same way.

As does color, so does sound, or rather the art-sense for sound, involve the psycho-physical emotions. Both color and sound are due to kinesis; color to the effect of vibration upon the eye, sound to the effect of vibration upon the ear; the artistic sound which we call "voice" is due to vibrations originating within the body itself. The kinesis is supplied by breath aided by the subtlest kind of reflections and refractions within the prismatic and pyramidal autonomies of the voice-tract due to the prismatic and pyramidal formations of its autonomies. The eventuation of voice-kinesis is at the lips, and, if perfect, it should eventuate in what may be described as a completed circle of diction and expression, faultless in power, resonance and pitch.

In preparing for its kinesis upon the organs of voice, physical breath, after it is under way, takes up an element of the psychical and becomes psycho-physical. Even omitting for the moment the consideration of the origin in the brain of voice, thought, voice-conception, or voice-impulse, there remains the fact that breath, after its intake through the nostrils (usually in greater quantity through the left nostril, where the psycho-physical sense of smell is more acute), passes under the floor of the brain immediately below the location of certain important senses. This process tends to vitalize it psychically; therefore, when it starts to act by kinesis upon the pyramids and prisms of the voice-tract through the motion and vibration it imparts, it has become psycho-physical. It is the psycho-physical breath which forms the connecting-link between the three forces of physiology, psychology and emotionalism, to which Vocal Art-Science traces the formation of tone as expressed in artistic voice.

This becomes even clearer when we recall, from previous statements, that the initial impulse to vocal tone occurs in the brain at a certain point and is carried by neurons to the various parts of the body concerned in voice-production. At the vocal cords, we have the pyramids and prisms at which breath-kinesis begins, where the actual conversion of breath into tone takes place; therefore, it may be claimed that at this point occurs the union of the physical and the psychical, of the mental process with the mechanical process of anatomy and physiology; and as far as the production of tone is concerned, it may be called the trysting-place of body and soul. May we not also say, harking back to the violet ray, that what the prisms of the eye are to color, the pyramids of the cords are to voice? Incidentally, and by way of analogy, the sense of hearing differs from the sense of sight in the relation of 1-10,000,000th of an octave. Forms, numbers and colors are sense-impressions in terms of light. Power, resonance and pitch are sense-impressions in terms of tone, and the coefficient between these, in rapidity of vibration alone, is said to be 1-10,000,000th octave.

The Purpose of the Following System of Vocal Art-Science Exercises

As regards the exercises which follow: The author does not treat them as rigid units, never to be varied. On the contrary, since it is impossible to bring out the subtlest points in any written set of vocalises, careful diagnosis, with careful watchfulness over the development of the pupil's voice, and slight changes to meet every new condition that arises, are essential.

He is aware that at any moment the student's tone may necessitate an immediate decision on the teacher's part to change from one exercise to another, or even from one kind of exercise to another, in order to meet a new phase of development. For the oft-told anecdote of Porpora and his greatest pupil, Farenelli, still applies. Porpora taught him, it is said, from a single sheet of vocalises, and sent him out into the world a great artist.

The story is perfectly logical. For though exercises have been written by the thousand, it is only the simple few with definite purpose and procedure that produce results. They must be fundamental, and adaptable to every phase of voice-development.

The author must not be charged with egotism if he claims that his exercises are rich in results; for what he has achieved with them must be attributed to the fact that they rest upon the bed-rock of voice-production—the principles of Vocal Art-Science.

By analysis and synthesis employed in this system of simple vocalises, the author's associate, Miss Adelaide Gescheidt, has accomplished the control of true fundamental and proper overtones for each and every voice. Each exercise refers, first, to the singing of the pure or first octave, the rounding of each note of the scale in perfect form; then to the development of the other overtones in their proper sequence with their fundamentals.

This system of vocalises is planned to bring about coördination of units of strength and correlation of the vocal autonomies in the functions which they perform in voice-production. This requires a definite training of the

central and sympathetic nervous systems and the harmonization of its centres. These are factors which Vocal Art-Science was the first to recognize; and in teaching, their definite training is accomplished by utilizing residual breath that always is to be found in the body, even after expiration.

The great nerve-centre for the adjustment of the sympathetic system, the solar plexus, keeps this system in perfect balance through the breath-clutch, as described earlier in this work. Without this balance, there would result hysteria, neurasthenia, and the kindred -thenias and -phobias commonly known. The definite breath-clutch governs the tone-centre, and balances all parts in accomplishing a perfect mechanical action of the vocal organs.

The clutch maintaining an equal downward pull for the larynx, the tone-centre or breath-resistance-point furnishes the forward pull, and the contact of the spine the up-pull. This produces perfect pyramido-prismatic action, action in terms of three planes, for the entire part of the body mechanically concerned in voice-production. With an absolutely perfect tone-centre, there is an equalization of tension throughout the vocal tract, and the tone automatically reaches down to its own correct hold on the breath-clutch.

The Artistic and Vital Breath the Automatic Part of Voice

The breath, first of all, involves the act of smelling as the normal inhalation, the deeper inspiration being by way of the left nostril, because the kinesis of the left side of the olfactory is much more finely developed, and is really the centre and controlling element of kinesis of smell.

The olfactory nerve-centre being so situated can increase or decrease respiration and even enable one to pause in expiration.

This shows conclusively the importance of the control of the psycho-physical breath, which is all in evidence

when the automatic breath-control has been established by definite training.

The exhalation is accomplished after the inhalation as above, by closing the right hand tightly and then instantly pressing it firmly against the upper lip, and at once puffing out the cheeks and allowing the breath-stream to flow like a sound of escaping steam, quite rapidly, but against the closed hand and through the closed mouth and gathered lips. At the same time, when the cheeks puff out, note the clutch that is evident just below the diaphragm, and also the expansion of the thorax. This development is accomplished *aside from singing.*

The definite way to control the automatic breath is through what is termed the "breath-clutch," which regulates and adjusts the whole breathing-tract, besides being a superior aid in adjusting the vocal organ. It is active throughout the training of the voice after free action of the tongue, jaw and throat is established.

The "clutch" takes on all the effort of the singing act and is the centre for controlling the emotions, as well as he mainstay of the singer at all times.

Application in Teaching

To gain practical use of the breath-clutch, pronounce the word "hook" in a decided whisper, twice short, pronouncing the "k" very distinctly each time. The third time hold the "k" a few seconds, then let go and at the centre where the "k" is felt (which is between the diaphragm and umbilicus) there is a decided inward clutch. Note also the rebound of the abdomen after the clutch is released.

It is here that the effort of breath-control establishes itself and one learns to make the attack for the tone that finds its resistance-point at the gums of the front upper teeth, after all constrictions of other muscular efforts are removed. Close observation must be made so that the chest-walls are allowed to take care of themselves through the support underneath by the breath-clutch. All other

conscious muscular effort must be done away with on the part of the student, as it would only mean constraint of the voice and hindrance to free emission of tone.

Coördination of All Muscular Action Necessary

To establish perfect coöperation of the various units of strength and autonomies as described in the foregoing chapters, true adjusting of the vocal apparatus and coordination of the entire respiratory tract are absolutely essential, if one would mentally control the natural emission of tone and maintain all of its elements for artistic singing.

There must be perfect coördination of every muscle of the body to ensure the normal mechanical action of the instrument, for the action of the tongue alone—the chief organ governing articulation and enunciation—and the direction of sound-current are simultaneous.

Activity and passivity of all muscles are essential to develop spontaneity, but must be entirely governed by the automatic breath-control. Inaccurate control of muscles produces inaccurate results of tone-production.

The more perfectly and steadily the muscular functioning on all sides of the torso, the more faultless will be the resonance and power of control for the perfect tone-emission.

Correlation means a harmonization of all autonomies or centres of force throughout the nervous system. This correlation is brought about by definite procedure through the establishment of the automatic breath-clutch and its controlling centre (the kinetic angle of distribution of force). By this all the autonomies are brought into perfect relationship.

The Initial Tone

Tone in its output must have a centre or point of resistance, and there must also be another centre of control for the breath. This combination gives not only contrapuntal action, but also definite support of voice. It insures

security of the adjustments of the vocal apparatus, which means perfect mechanical action.

A wise suggestion is to begin tone at its point of resistance and not its point of departure.

The point of resistance for the initial tone in its output is on a direct line with the roof of the mouth and is sensed against the gums of the upper incisors. This is therefore the natural place of resistance of the breath in exhalation, and is the place of tone-impingement and the mirror of the psycho-physical element of voice, and also the correct position to sustain the poise of the larynx, mechanically speaking.

"Voice Direction" versus "Voice Placement"

Voice placement, having such a variety of conceptions, is not countenanced in Vocal Art-Science, as it localizes and fixes tone in the mind of the student as being in one place. It is, therefore, a suggestion that is misleading; for tone, through the sevenfold pathway, operates through the entire body and not at any one particular spot as so many students regard it, in their knowledge of so-called voice placement. "Voice Direction" is the correct term.

A Few More Points Regarding the Following Exercises

When a breath is required after a phrase, a simple breath-clutch is all that is necessary to propel and support voice. Nature prompts the filling of the lungs for vital processes. An intentional inhalation is not correct for perfect tone-emission.

Each figure must be vocalized in one key after another, either ascending chromatically or skipping about between the pitches designated. Low B♭ is the best pitch to begin on, as it gives maximum power and quality of tone and overtone. It is the preparation for coördination of the next octave above.

There is no steadfast rule for vocalizing any of the following exercises. To ensure results, all vocalizing must

be done with ease and spontaneity. Working the mechanism on only a few notes will bring quicker results than any attempt to bring the whole range of voice at the start into action. The latter might cause a strain, and in the end miss the result which exercising in a reasonable way is bound to bring.

By focusing is meant to gather the lips well together as in forming "Ō" or "ōō."

"Ah" preceded or followed by a consonant always means the use of the broad "A" sound, as in *father*.

A teacher must be so keen in analyzing voice that he will apply just the particular strengthening of an individual unit necessary, or remove superfluous effort of a part or unit in the mechanism, by use of the following vocalises.

The consonant is the "lead-out" for the vowel, and is of vital importance.

Vocalises for Development of Voice in a General Way and the Mechanical Action of Its Instrument

We find in nearly all cases that the student has little or no freedom of the lower jaw. The same can be said of the action of the tongue. These parts, especially the latter, are the most important for articulation and enunciation; therefore, the first step is to release stiffness and constriction of the jaw and tongue, before attempting anything else in vocal exercises.

These impediments removed, the path is cleared for greater control of the points to follow; this ultimately results in a definite understanding of the natural and artistic emission of tone.

Vocalises for General Use in Voice-Development. Vocalise No. 1

Use Figs. Nos. 1, 2, 3 and 4 separately with syllables as directed, in a medium tone of voice.

A definite drop of chin should be made for each syllable, especially on the upper notes; and the tip of the

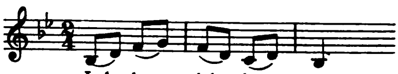
tongue must be allowed to rest against lower teeth when not in use for pronouncing; lips flexible:*

Flă - flă - flāy	Sproo - sprō - spră
Thä - thä - thā	Splee - splā - splä
Splä - splä - splā	Vä - vō - vā
Maw - mä - mā	

No. 1. Allegretto†

No. 2. Allegretto†

No. 3. Andante†



No. 4. Andante†

In the vocalises pitch is indicated as follows:

*Commence as a rule on low $b\flat$. For high voices continue to g^2 or $b^2\flat$ if as comfortable as singing at e^2. For low voices continue to e^2 if as comfortable as singing at middle $b^1\flat$.

†The above combination must not be taken in a capricious manner; the action of the jaw, lips and tongue should be carefully noticed in vocalizing.

Tongue-Exercises

The following tongue-exercises are to be used aside from singing to get quick results.

I. Rest tip of tongue against lower teeth, and keep mouth well open. In this position roll the tongue out of mouth and press it forward, conscious of a good pulling at the base; then let it slip back to its normal position, without a deliberate jerk. Repeat four times.

II. Rest tip of tongue against first lower bicuspid tooth on the left side of mouth, well opened. In this position press the tongue forward and out of the left corner of the mouth, and then allow it to slip back again, while the mouth remains open. Repeat four times, and then exercise from right corner of mouth as well. The number of times may be measured, as stiffness begins to disappear. This will be apparent when the pulling from the base and side muscles of tongue ceases.

Use the following figures and combinations of consonants and vowels for tongue-freeing in the singing-voice. This combination is also excellent for centering of the tone in its output.

For these exercises rest the tip of the tongue against the lower teeth, then roll the tongue slightly forward until sides are seen between jaws.

Vocalize No. 5 up to $c^2\sharp$ if comfortable; then descend chromatically, singing the same way on two scales below this pitch on syllable "Nee" each time. Then No. 6 must be vocalized in the same manner on combination "Nee-ay," and descending chromatically on a few scales as noted for No. 5. The tongue in same position as at the start throughout figure. Low voices to vocalize a third lower.

No. 5. Andante

No. 6. Andante

To get quick response of tongue and also to train the tone to centre, to fulfill its requirements in its true position for emission, use the following figures and syllables:

No. 7. Allegro

No. 8. Allegro

The palate may now receive training for its functioning in voice-emission. This will strengthen the union between first and second octaves of resonance (sonoric vocalic-resonantic).

No. 9. Andante

Sing the above figure up five steps in the key sung, repeat fifth note, and descend. Five syllables on one note, and so on up. Breathe between each group.

Sing thus chromatically as high as c^2 or d^2.

Pronounce "K" very decidedly and crisply. Feel decided action of breath-clutch on the K.

No. 10. Andante

These figures are to be sung on the ascending scale note by note chromatically up to d^2 for high voices; and for low voices a third lower, ascending to a.^{2}

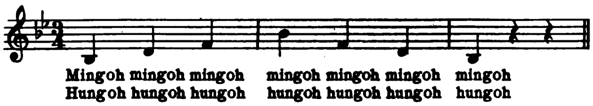
No. 11. Allegretto

No. 12. Andante

No. 12. Vocalize up to the fifth above; repeat fifth note and descend. This must be done slowly enough to get a strong palate sound with letter K, noting carefully the action from the abdomen and clutch, especially with No. 12.

No. 13. For strengthening the fauces, focus the ō well into the lips. Use up to e^2.

No. 13. Andante



The Centre of Resistance for Initial Tone

The student must constantly be reminded of the point of resistance, or natural place of impingement or centre for tone, as it goes forth and detonates into its various resonators.

If the student will study a sigh (*spiritus lenis*, the Latin for soft breath) that is more like a vital whisper, directed against upper gums, pronouncing first the vowel "E" on a sigh, then vowel "Ā" also on a sigh, he will consciously and mentally find the centre of resistance of tone. Next, with the sensation of the sigh fresh in the mind, and on the same rhythmic beat, direct with a sing-

ing staccato tone the combination of Nee and Nay, separately, at an easy pitch from $e^1\flat$ to g^1.

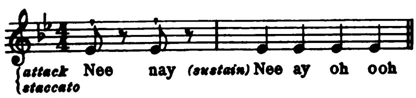
At this same point of impingement or centre of resistance, which really becomes a mental target, sustain "Nee-ay-oh-ooh."

The jaws must be far enough apart to allow the little finger to be placed between the teeth and remain there throughout singing of the following figure, to ensure a steady larynx, and suggest the mental direction of the output of tone and flow of breath through mouth.

For example:

1. Sigh "Ee" and sigh "Ay."
2. Attack "Nee" and attack "Nay."
3. Then sustain "Nee-ay-oh-ooh."

No. 14. Andante



To be used at various pitches not higher than $c^2\sharp$, and not lower than c^1 for high voices; a third lower for low voices.

Through this conscious control of the resistance-point of the initial tone, the student can train accurately and definitely a balance of all resonators, and correlate sympathetic vibrations. The latter are finally concentrated at this one particular centre, and tone and word are as one. The centre of tone-emission is then assured.

If the lips tremble during the training of centering of the tone, it is only an indication of the correct focussing of the voice. This will disappear when the muscular strength manifests itself, and tension develops to the fullest degrees in the lips and all the sphincters.

To Strengthen Resonantic Unit

No. 15. To concentrate the voice in the nose, and at the same time to create activity of the upper resonators, put the following into practice:

Hold the forward part of nostrils slightly together with thumb and forefinger, or close off the "M" resonator, with lips loosened from the teeth, and then thrust forward; sing combination "Nee" with the tone centered and directed forward, just where the nostrils are held by the fingers.

Sing on the following figure and repeat on every note below; vocalize up to *e*², or to middle *e*¹ for high voices. Low voices may begin and descend lower.

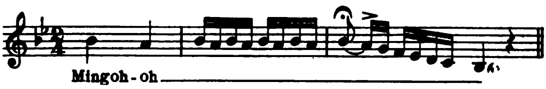
No. 15. Allegretto

No. 16. To concentrate voice and polarize the resonantic unit, sing syllable "Ming-ō" directed entirely through the nose, lips thrust forward and free from the teeth.

To be sung as high as *e*²♭ for high voices, and a third lower for low voices, if comfortable. No tightness or effort of the throat should be apparent.

If the "breath-clutch" be accurate, all constriction will finally disappear.

No. 16.



NOTE. A dovetailing with upper octaves, vocalic-resonantic; double octave overtone forming spaces.

No. 17. To sing through the resonantic unit, and also coöperate with the forward vocalic resonance or resonantic vocalic combined, sing "Mō,"—centering tone against gums of front upper teeth. To be accurate in the emission, always place middle finger between the teeth when starting the tone, until the larynx is balanced in its position and the direction for tone is perfected. This prop can then be removed.

The tone thus directed will have such a clear free ring that one will readily recognize his own nasal resonance.

Sing on following figure:

No. 17.

The following exercises are for the development of the adjustable and divided octaves of resonance; also for automatic blending of vocalic-resonantic units or adjustable octave by the tongue and the divided resonantic octaves, divided by choanæ into naso- and oro-pharynx.

Nos. 18-22. Generally speaking, it is best to train the student to energize and open up the forward oral and nasal resonators in preference to the lower and deeper sonoric one. These exercises will also strengthen resonantic and vocalic units.

Use the following figures and syllables to ensure above results:

No. 18. Andante

No. 19. Andante sostenuto

No. 20. Andante

No. 21. Andante

No. 22. Andante

Sing up to f^2 for high voices after a certain time of usage; low voices should start these exercises a third lower.

To gain the best results with the above exercises the following suggestions on the use of "Nō" and "ōō" *must be observed:*

The consonant "N," pronounced in its attack by placing tip of the tongue against gums of upper front teeth, with a pause long enough to start a short hum there.

Mentally direct the "Ō" forward at this spot where the hum is felt, and focus into the lips.

The pronunciation of "N" and "Ō" must be simultaneous.

The tip of the tongue, immediately after the hum, drops to its natural position against the lower front teeth. "Ōō" must be used here in singing the higher notes of the figures, so as to coöperate with lower and higher resonators, thereby also incorporating all the octaves of the voice at the same instant.

This is accomplished after use of the above for a short time by starting exercises on e^2 and going to $f^2\sharp$ and on descending notes, thereby working directly into the dome and head resonance and blending it with the vocalic or sonoric. Not to be sung any higher except on Ex. 22, which may be carried up to a^2 with the best of results, if it can be sung with perfect ease.

Scales of Vowels and Consonants

At this juncture the use of the scale of twelve vowels and twelve consonants and vowels must be put to practical use. These scales have been arranged with such discrimination in their sequence in Vocal Art-Science, that by their correct use each and every resonator from the tip of the nose to the glottis is exercised, and finally all are correlated. Perfect articulation is the natural result.

With the use of the scale of consonants and vowels all the muscles for articulation and enunciation, namely, the lips, tongue and palate, are exercised and developed, and perfect pronunciation is the result. Correct diction is a natural sequence.

For practical use, vocalize as follows:

No. 23. Scale of twelve vowels, to be sustained on an easy middle pitch; F or G is suggested, as at these pitches all the tone forces are assembled more perfectly.

So that there can be no varying of position of the emission of tone, again use the finger between the teeth in the initial attack of the vowel "E." This will hold the vocal apparatus on as good balance as possible at this stage of voice-development.

With the mind directing the sound-current at this centre sustain the tone on an easy speaking pitch and begin as follows:

Scale of Vowels		Scale of Consonants and Vowels	
ē	pronounced as in eat	Pē	pronounced as in peek
ĭ	" " " it	Bĭ	" " " bit
ĕ	" " " end	Mĕ	" " " met
ă	" " " at	Nă	" " " nap
ā	" " " ate	Dā	" " " day
ī	" " " eye	Kī	" " " kite
ä	" " " ah	Rä	" " " rah
ŏ	" " " ox	Lŏ	" " " lot
ōō	" " " ooh	Tōō	" " " too
ū	" " " you	Fū	" " " few
â	" " " awe	Gâ	" " " gawk
ō	" " " oh	Vō	" " " vote

No. 24. This scale of consonants and vowels should be sung chromatically, beginning on the scale of B♭ for high voices and low "G" for low voices. At least 5 keys above should be employed. The order of the scales of vowels and consonants should be reversed on descending scale; i. e., beginning on a high note with syllable "Pē" instead of "Vō"; and descending in sequence as above, scale after scale, to B♭ again.[1]

"Aw," or Sonoric Resonator

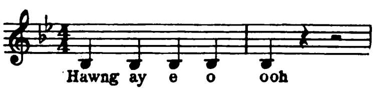
The opening and exercising of the sonoric resonator reinforces the tone and gives a deep and rich quality to it. For the training of this space, note the following:

Take a breath through the open mouth, and the spot at which the cold air strikes at the back of the tongue will reveal its correct location. Another way is to produce the vowel "Aw" aloud and note its vibration low in the throat.

No. 25. The following exercise is to develop the sonoric unit for tone reënforcement:

With a very slight movement of the jaw and tongue, without stiffness, sing and sustain the following on separate notes chromatically up to b^2♭ or c^2 for high voices, and g^1 for low voices, beginning at low *b*♭ for the former, and low *A*♭ for the latter (if tone comes without effort); otherwise, to secure this development practice on a few notes will suffice.

No. 25. Andante sostenuto



[1]To prevent confusion in the arrangement of vowels and consonants and their correct sound, the scales have been simplified by the use of syllables or words to give correct pronunciation. This direct marking for pronunciation will, it is believed, prove a great aid in establishing a correct vowel-system.

Regardless of the singing position or articulation, allow each vowel following "Hawng" to remain at the location or vibration of the vowel "aw." This is not to be confused with the correct singing position. The thought of yawning will aid also to this location.

Nos. 26, 27, 28. To be used with the correct singing position. Direct the tone through the vocalic and at the point of impingement, each tone blending into the other. A perfect legato should be used; while the position remains the same as on the first note sung. The only change manifested is that the lips close more for the vowel o and protrude for vowel â.

No. 26. Andante

No. 27. Andante

No. 28. Andante

Note. Exercises 26, 27 and 28 may be used, after a period of practice, on "Whoa" and ōō in place of hâ and ō.

Arpeggios and Scales

These may be installed now as beneficial to the progression of the voice. Also slow melodious and legato standard vocalises are suggested.

The idea at this stage of development is to apply the voice as in the preceding exercises that designate the use of the tone-centre, breath-clutch, and dropping of chin for each new vowel and syllable; with tip of tongue resting against lower teeth when not used in pronunciation. Use the middle finger between teeth, or the "ah" index, so as

to assure a correct position for the larynx and direction of tone forward on the start of each phrase.

· The use of such syllables as "Nō," "Mâ" and "Lä" for deeper resonance, and "Nā," "Lā" and "Lē," and sometimes "Nē," for higher and forward resonance; also the same vowels, beginning with "M" as the initial consonant.

The following arpeggios are for general use:

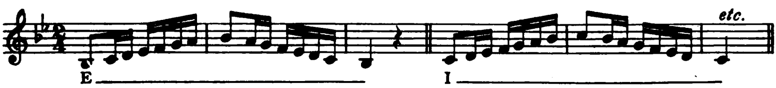
No. 29. Adagio sostenuto.

No. 30. Andante

Alternate with syllables "Maw," "Whoa," "Nō," "Nä" and "Vä" on Nos. 29 and 30.

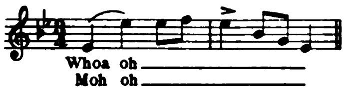
No. 31. Sing plain scales on the major vowels e, ī, ä, ō, â, separately, starting on scale of low B♭, and ascend in sequence of scales to middle F; then reverse order of vowels, starting again on middle F, but using vowel "E" instead of "Aw," and then in regular order again on the ldecending scales to B♭. The low voices start at A♭ or ower, and ascend to fifth above. Then reverse order of vowels, and descend scales to B♭ again.

No. 31. Andante



Nos. 32, 33. For stretching vocal cords and general loosening of throat, sing the following:

No. 32. Andante



No. 33. Andante

The direct point of tone-resistance, or mental target, must be always definite for every tone sung; i. e., directly against gums of upper front teeth at all times.

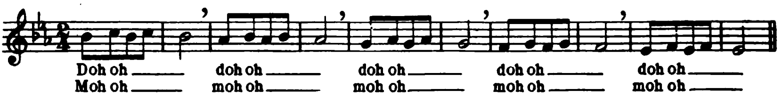
Blending of Voice Resonance

No. 34. In order to train and test the balance of adjustments of the vocal apparatus and gain better poise of tone, place little finger between teeth, tongue rolled slightly over and forward. Then sing the following exercise, alternating with syllables "Nē" and "Nā."

No. 34. Andante

No. 35. To blend resonance, balance the voice-quality and train the *mezza voce*, using the light attack with easy mechanical action of the vocal instrument, the following groups of vocalises are most important.

No. 35. Andante



Sing in any key that the voice will respond to. Use very soft, mellow quality of tone. Round the vowel ō by correctly gathering the lips.

No. 36. Andante

No. 37.

Above to be sung lightly and purely, *mezza voce.*

No. 38. Sing up to the fifth above keynote. Repeat fifth note, then descend; sing as much of the figure on one breath and ascend as high as possible with ease.

No. 38. Allegro

These syllables must be sung lightly and softly, and directed into the lips and through the nose by thought only. This is a means to an end in perfecting the artistic quality, and should be practiced only after the mechanical action of the voice is good.

No. 39. Sing the following *mezza voce*, in soft, even, mellow tone, with artistic feeling and phrasing. Very legato.

No. 39.

The Mechanical and Artistic Tone-Quality

To develop an understanding of the tone of intensification of resonance and the one of amplification of power, Exercises 18, 20 and 22 should be used on the combination "nē" and "nā" (alternate these two syllables on these figures). The tone must be quite accurately directed to produce the best results, and should be started very definitely at its place of impingement against the gums of the upper front teeth. This combines the tone-quality made by a good vocal mechanism with the voice-box contacting the spine—which establishes individual quality of voice. This procedure is the open sesame to power.

Only the forward and upper resonators are in operation with the tone of intensification (resonantic, vocalic, and non-sonantic), nose, mouth, teeth and lips. This tone must be concentrated to the front in its output.

The quality of tone thus produced may be raw and over-resonant in this procedure, but it means that if the direction and resonance is accurate and the vowel pure, a perfect mechanical action of the vocal apparatus is assured in the course of time and practice.

The breath-clutch works very powerfully and surely, the entire vocal apparatus is at its utmost tension, and the most perfect adjustment is possible in the singing with this mechanical tone-quality.

The development of the artistic or individual quality of voice may now be considered.

This quality partakes of the tone of intensification of resonance with its increased forward pressure at the point of resistance against the gums of upper front teeth.

To this is added an expansion at the back of tongue in the "Aw" or sonoric resonator, at which instant the fifth cervical vertebra of the spine is contacted. A positive forward pressure of the tone and a posterior expansion in the throat is evident at this point.

The lowest and deepest resonator is incorporated in this act, and a great feeling of freedom and openness ensues in the throat, and vocal assurance is established.

The sympathetic vibrations of the body are now correlated with the sound. The individual quality or timbre of voice can be operated with any degree of amplification. The pure *messa di voce* is possible. Through mind and emotion—thought and feeling—the singer is able to deliver, with the highest perfection, humanly attainable, the finest expression of his artistic self in interpretation.

As a direct consequence of Vocal Art-Science practically applied, Bel Canto is naturally established, and upon a basis so absolutely correct, that, were it accidentally to be lost, it could be regained under instruction by definite procedure.

The author has incorporated these exercises in his book because Miss Gescheidt has applied to her teaching of voice the principles of Vocal Art-Science, as set forth in the foregoing pages. She has developed a complete course of instruction based upon his theories, and has thus demonstrated in actual practice with her pupils, and in the remarkable results achieved, that Vocal Art-Science is no individual fetich, but a living truth, because derived from natural laws hitherto neglected.

By these added practical means to the author's efforts the future of this Vocal Art-Science cannot possibly fail to be perpetuated throughout posterity.

AFTERWORD

In concluding my work I wish to reveal to the profession a few comparative facts drawn from the vocal temples of three of our foremost living singers, which I have had the great privilege to examine and to measure. Their names, as well as measurements, are purposely withheld (as patients). The vocal structures under consideration are those of two of our greatest tenors and our foremost soprano.

It is very difficult to compare structures, each of which stands as our only existing models of physical, mental and psychical vocal art. Therefore I can indicate only some of their physical and structural variations.

Their vocal tracts are exquisitely built in their entire extent—from the lower Dynamic unit to the Resonance-chambers above—for translating, correlating and producing marvellous combinations of Power, Resonance and Pitch of Vocal Tone.

Extraordinary and powerfully developed lung and chest capacities afford mighty reservoirs of force, notable in classing these artists among the superhuman.

The vocal cords show some interesting variations, one set being very remarkable for the massive structure of the vestibule between the true and false vocal cords. By this unusual physical development the control of voice that is demonstrated, enables the artist to electrify and thrill his audience in a most astonishing way. The vibratory qualities in this structure were truly wonderful. In one case the cords were over one eighth of an inch longer than those of any other artist I have ever observed. The other pairs of cords having the same range are more finely modeled and delicate in structure, those of the tenor being slightly larger and heavier than the soprano's, but in each case larger than normal and well marked.

The insertions of the cords upon the arytenoids are interesting in the soprano, in that they demonstrate clearly

a sharply-defined right-angled attachment to definitely pyramidal arytenoids. The arytenoids of the two tenors stand out less sharply, owing to the attachment of heavier cords.

Possibly the most notable and interesting contrast exists in the types of epiglottidæ. One massively proportioned, with enlarged and rounded base tapering gracefully to a thin scoop-shovel tip, the entire structure much longer than normally observed, yet retaining remarkable flexibility and pliancy.

The other two types are modeled more delicately, terminating in the perfectly-formed triple-curved tip which I have rarely observed so clearly in any other cases.

The muscular autonomies of the tongue and palate, combined with the coördinated jaw, border upon faultlessness in their precision and adjustment. The oral and nasal cavities of each are more extensively developed than usually found, allowing an increase in the volume output.

Each vocal canal is lined throughout with a delicate pink and unblemished mucous membrane, so perfect in contrast with the cartilages in the pharynx of the soprano, that they stand out like pearls in a sea of pink.

These ideal models of physical perfection, exquisitely controlled and regulated by keen artistic mentalities, combined with remarkable qualities, place these wonderful artists as true sponsors of the God-given Voice Divine.

Another interesting type of vocal adjustment has been brought to my attention recently by several artists possessing the "Bird" voice, or whistling, as many prefer to style it. All of the qualities essential to the beautiful voice were present, pathos, style and expression, without the use of diction as supplied by the lips and jaw. The unusually perfected ability for adjustment of the tongue and palate, coupled with remarkable powers of tone-perception, all combine to add to the beauty, dexterity and fineness of the tone-production.

The perfectly poised vocal tone of speech and song is the open sesame to personality and temperament, or that refined yet ever evasive soul-expression which every well-organized personality craves and is ever responsive to.

Year upon year master and pupil have endeavored to establish laws in explanation and development of pure tone-formation. Much beautifully formulated knowledge has been gleaned, but failure has crowned each effort, solely because more attention was given the growth and nutrition of the mighty *material* tree, without minutely studying the acorn to which it owes its existence.

With the stimulus of 32 years of active medical experience, during which over 200,000 applicable cases have come under my observation, as well as years of instructive personal experience in vocal art as a foundation, combined with extensive reviewing of all vocal literature, it has been my keenest desire to produce true Vocal Art-Science.

By incorporating the valuable knowledge gleaned from Phonetics, Vocal Art and Medical Science into a true Vocal Art-Science and demonstrating its wonderful scope I have endeavored to establish for you the wonderful lineage of voice-formation from its creator to the spellbound audience.

With this stretch of pathway ever in mind, I hope to bring forth a new volume for further study relative to newly established scientific facts and methods as well as explanations of many recently perfected mechanical devices of practical interest to both the student and the practitioner. The materialization of the long cherished ideal for the necessity of a method of voice standardization is in the form of an Electro-Audion Sustained-Tone-Producer, a device by which simple and complex sustained musical tones may be produced at will. A telephone has also been invented which will faithfully and reciprocally produce the human voice entrain without a pitch period interference; also in consonance and harmony.

By listening attentively to the song of the wheels of progress we ascend to the ideal of perfection. It is perhaps not within the compass of one short life to do aught but firmly establish and build the structural framework, while the completion and ornamentation of God's most beautiful temple remains for those of you who, through inspiration and keen insight, endeavor to carry ever higher and higher the perfection of the knowledge of scientific Vocal Art for the enlightenment and benefit of mankind to come.

I wish to acknowledge the valuable assistance rendered me in my research work by the following:

Mr. Frank X. Ahrens, Dr. Charles S. Bentley, Mrs. Herbert F. Brown, Mr. and Mrs. Howard H. Brown, Dr. William Sohier Bryant, Mr. Dudley Buck, Miss Eva J. Brummer, Mr. William Courteney, Mr. Leonard Day, Mr. L. Stewart Gatter, Mr. Frederick Shand Goucher, Mr. Herbert Wilbur Greene, Mr. William J. Henderson, Mr. O. E. Hagen, Mr. Victor Harris, Dr. Carl Martin, Mr. Holmes W. Merton, Dr. James A. Moffat, Miss Eleanor McClelland, Mr. Edwin Fairfax Naulty, Professor Eglebert Neus, Professor Frank R. Rix, Mr. Louis Arthur Russell, Professor Carl E. Seashore, Mr. Edgar S. Werner, and Mr. Clifford G. Weston.

For illustrations I am indebted to "Gray's Anatomy," "Lehmann," "Lehfeldt," "Miller-Merton Atlas," and "McClelland's Anatomy."

Original drawings were made under my direction by William Fraetas and Karl Kraft.

SUPPLEMENTS

TUNING-FORK TESTS

with

MISS HELEN KELLAR

by

Dr. William Sohier Bryant for Dr. Frank E. Miller

C- 128: Felt vibration strongly on palms of hands.
C- 512: Felt vibration strongly between lips, and on fingers.
C- 256: Felt vibration strongly on knee, not on elbow.
C-1024: Felt vibration faintly on fingers and lips.
C-2048: Hard to tell; doubtful.
C-4096: At first thought she had slight vibration; doubtful.

In Testing With and Without Tuning-Forks

	With	Without
2048:	Yes (very positive).	No (very positive).
4096:	No.	No (very positive).
Again:	Upper lip. Doubtful.	No (very positive).
Again:	Upper lip. Quite sure.	

On Index Finger of Right Hand

C- 512: Very positive.
C-1024: Quite sure.
C-2046: Uncertain.
C-4096: Same relation as on lips.

Tests for Harmony and Discord Through Fingers

G- 96 and C-128: Discord; very positive.
C-128 and G-212: Harmony; very positive.
C-128 and C-128 (one thrown off): Recognized as "rough."
64 and 64 (one off): Feels discord on rising pitch of one of them.
128 and 128 (one off): Same effect.
G-212: On ankle. Very perceptible.
G-212: Frontal sinus and vertex. Nothing.
G-212: Glabella. Very much.
G-212: Mastoid. Nothing.
G-212: Chin. Nothing.

With Adelmans-Galten Whistle

17 point, 3-pt. (by air force):	Very painful "pushing" in ear.
18 point, 3-pt. (by air force):	Very painful.
21 point, 3-pt. (by air force):	Very painful.
27 point, 3-pt. (by air force):	Very painful and disagreeable.
15 point, 3-pt. (by air force):	Does not affect her at all.

High pitch sensations: Practically normal, but found that if high pitches were made very loud, they were extremely disagreeable. Perception of high vibrations in ear not gone. No sense of vibration of low notes anywhere around the ear. (*Very remarkable.*) Ordinarily deaf mutes are most susceptible to low notes. Miss Kellar does not feel low notes at all.

Several minutes afterwards: Ears are decidedly uncomfortable from high pitch sounds.

Observation on Ears

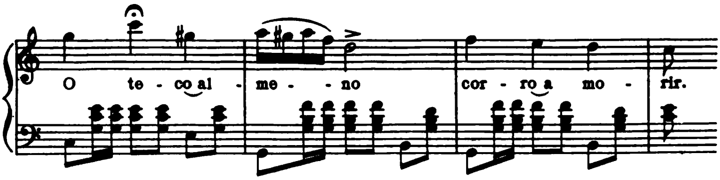
Right Ear:	Retraction of drum membrane, second degree. Small light reflex. Slight waxy color. (In other words): Intact drum membrane.
Left Ear:	Much like the right; reflex a little smaller.

Miss Kellar complains of speaking loud or "yelling in her ear." Very disagreeable to her.

Miss Kellar also wanted to know "What makes the rattling sensations when riding in a carriage over stones?" Was told it was the jarring of the middle ear.

She has no sense of direction or equilibration.

WHEN CARUSO SINGS "HIGH C"



The eight plates which illustrate this article form a photographic record of the vibrations of Caruso's voice, when that distinguished tenor sings "o teco almeno corro a morir" in "Trovatore." It is on the vowel "e" in "teco" that the high C (c^2) occurs, a note not written by Verdi, but introduced and, when introduced, quickly established at this point in the opera, a test of a robust, high tenor voice. In point of fact, however, since it has become necessary for tenors to sing the high C in "Trovatore," or eschew the opera entirely, the number is often transposed, so that the singer can deliver an alleged "high C" on $b^1\flat$, which is only half a tone higher than a^1, the usual boundary note of the upper range of the tenor; all of which is not only interesting, but true. When the Caruso record was made, however, the tenor sang high C.

The original records are on sheets that measure about 12 by 8 inches and on which the sequence of the vibrations are shown in a series, which must be imagined as pasted together and unrolled from a reel. Were this done, it would be found that Caruso's high C was held so long that, were the strips recording it pasted together, they would measure fifty-eight feet. While one cannot say that Caruso's high C in "Trovatore" is fifty-eight feet long, the fact that its record required that length of strip proves that it was superbly placed and held.

This fascinating record was made by Dr. W. E. Scripture for the author. The explanation of the plates and the notes that follow are supplied as the result of a conference between himself, Dr. Scripture and others, the author determining the phrase selected to be analyzed.

Plate I. This plate begins with a record of the vowel "o" as the singer begins with "o teco almeno," etc. The vibrations are seen to be arranged in groups of two. Each group corresponds to one vibration of the singer's larynx; such a group of vibrations will be termed a "vowel wave," according to the best recording devices obtained from the Carnegie Institute. The vowel waves at the start are very faint; they gradually increase in loudness. This is a record of the gentle beginning which is found in most of Caruso's initial vowels. The vowel "o" lasts through the middle of the eighth line. The height of the waves rises and falls, indicating that the vowel is sometimes louder and sometimes weaker. It swells to the maximum height just before it closes, showing that Caruso ends the vowel loudly and snappily. This is characteristic of most of his vowels, as shown in the following plates.

The form of the vowel wave, i. e., its completion out of minor vibrations, changes steadily. This indicates that the sound of the vowel varies. The waves in line six, for example, show different vibrations from the waves in line one. On the other hand, certain similarity of the waves throughout the whole vowel exists. It is noticed that at nearly all points the wave group consists of one large vibration and another a trifle smaller; this indicates the presence of the overtone produced by resonance, an essential in voice-production known to every advanced student in vocal art-science, nearly but not quite an octave above the tone of the larynx. The record thus shows that the vowel has the sound throughout, but that its character changes from time to time.

Following the "o" there should be a record of the sound "t." For this sound the record should be an absolutely straight line, because the larynx does not vibrate during "t." It shows, however, fairly strong vibrations from the middle of the eighth line to nearly the middle of the ninth. These prove not only that the larynx vibrated during this time, but also that the tongue did not closely contact the teeth for the "t." The "t" with vibrations of the larynx is termed a sonant "t," resembling rather a "d"; and a "t" with a loose closure is termed a fricative "t,"

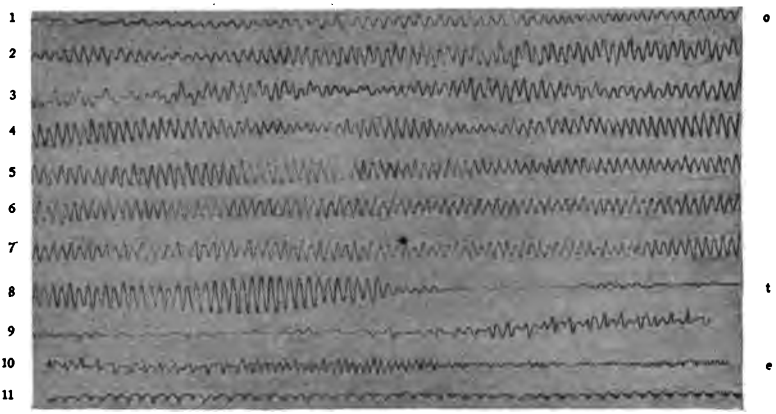


PLATE I

Begins with vowel "O" of "O teco" etc. This continues to the eighth line, where the singer begins to prepare for the high C, which begins about the middle of the ninth line

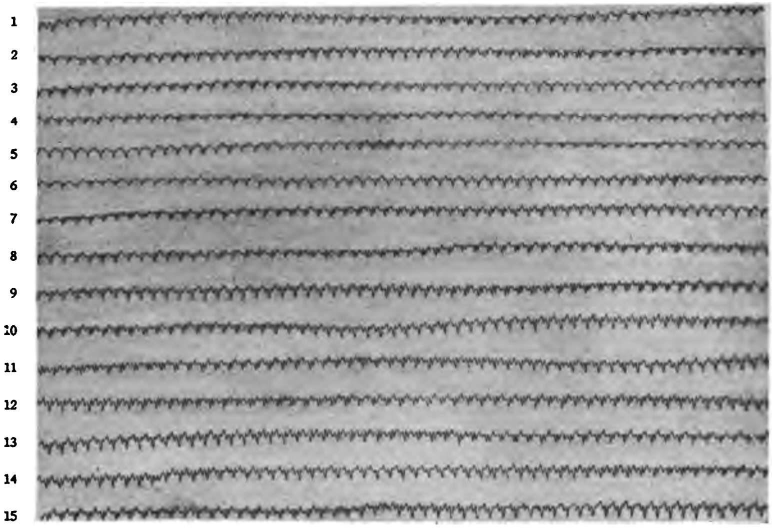


PLATE II

This entire plate shows the continuation of the high C

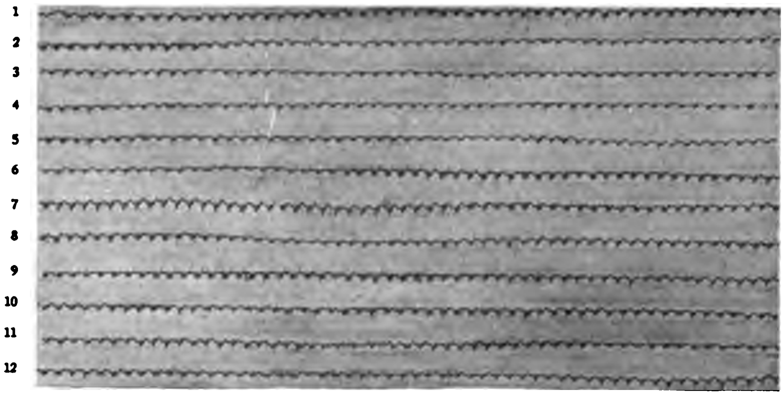


PLATE III

The high C continues throughout this entire plate

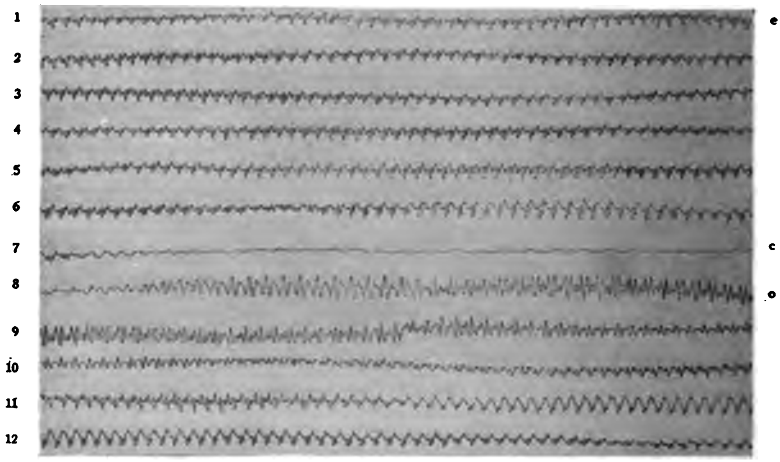


PLATE IV

The first six lines continue and end the high C. The remaining lines show the syllable "co" of "te-co"

resembling a "th." Thus the sound at this place was not on a true "t," but a sonant fricative "t" resembling the "th" in "there."

The reason for the substitution of this sound for a true "t" is obvious. The larynx vibrates during the preceding vowel and during the following one. Moreover, the singer is preparing for a supreme effort in the following vowel on high C. It would be a more difficult adjustment to interrupt the laryngeal vibrations for a moment to make the "t." It is much easier to let the larynx continue to vibrate during this short time, just as it is easier to slow down a car for a moment than to suddenly stop it and start it again.

The vowel waves beginning in the ninth line of Plate I become shorter and shorter. The length of the vowel wave registers the pitch of the tone from the larynx. The voice thus rises rather rapidly to the high C, on which the tone is sung.

Plate II. This continues the record of the vowel "e" on high c^2, from Plate I. The vowel wave is very constant in form, indicating that the vocal quality remained unchanged. It varies slightly in length, undergoing some slight fluctuations in pitch. The high C was continued for a long time, the record occupying over fifty feet of the strips of paper on which it was obtained.

Plates III and IV. Of these two plates, the former continues another portion of the vowel "e" on the high c^2; while Plate IV shows the close of the vowel on high C. The vowel is followed by the consonant "c," which is the sound of "k." The record here should be an absolutely straight line because the larynx does not vibrate during "k." Yet the vibrations recorded here show that the larynx did vibrate. The sound was thus a sonant "k," made so doubtless for reasons similar to those that influence the vibrations on "t."

The vowel "o" occupies the next two and a half lines. At the start it shows considerable resemblance to parts of the vowel "o" of Plate I. The wave character rapidly changes, however, showing that the "o" sound is altering in character. The change becomes greater until we have

the typical vowel wave for "ä" (pronounced "ah") in the latter part of line ten.

Plate V. This begins with the vowel "a" of the word "almeno." With the end of the second line the vowel waves change to those for "l." These in turn change for "m." Both of these are faint, short sounds. The vowel "e" starts in with almost full intensity. Its waves for a while resemble those of "e" in "teco." Beginning with the end of the sixth line and extending to the end of the eighth, a curious deformity of the vowel waves is noticed. They no longer have the regularity of the ordinary vowel. They rise and fall and have their shapes modified, just as though some longer vibrations were interfering. The other vibration has a length that varies with the first part of the vowel "o."

Plate VI. The first four lines of this plate contain the latter portion of the vowel "o" of "almeno." The following lines are records of the accompaniment.

The latter portion of line eight shows vowel waves which continue through a large part of line nine. There are too few of them to be the record of even a short vowel in song. By studying backward from the close of the plate we can determine what they are. The last two and a quarter lines of the plate are a record of the first vowel "o" in the word "corro." This must be preceded by a record of "c," which is pronounced like "k" just as in Plate III. This "k" is sonant instead of silent. The waves in lines eight and nine are, therefore, a record of the short sound which preceded the "k." Carefully listening to the disc enables the ear to detect a minute vowel produced before the "k."

Plate VII. The first two lines of this plate give the last part of the vowel "o." It has the loud, snappy ending noticed in Plate I. The next line gives a record of the rolled "r." The fourth and eighth lines give a record of the final vowel "o" of "corro" with the vowel "ä" of "a morir." These two vowels are united into a diphthong. This diphthong also has the strong, snappy ending already referred to. The vibrations of the "m" are seen in this line. The last two lines show the vowel "o."

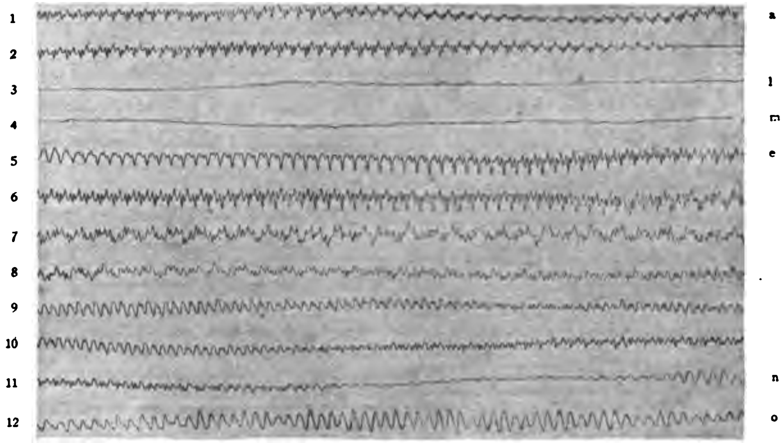


PLATE V

This plate registers the word "almeno"

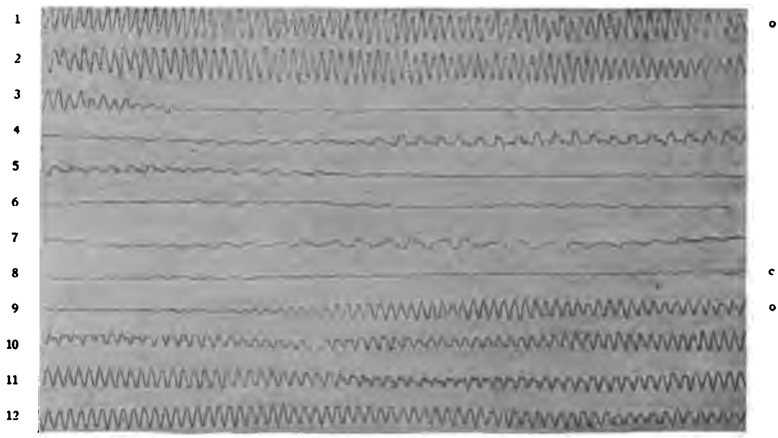


PLATE VI

The first nine lines give the vowel "o" of "o corro." The remaining lines give the "co" of "corro"

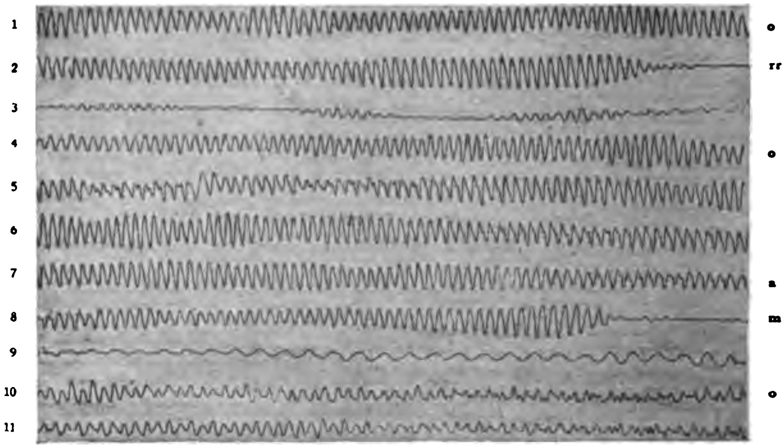


PLATE VII

The first line continues the "o," the second and third lines give the "rr," and the fourth, fifth and sixth lines give the final "o" of "corro." The remaining lines give the "a" and "mo" of "a morir."

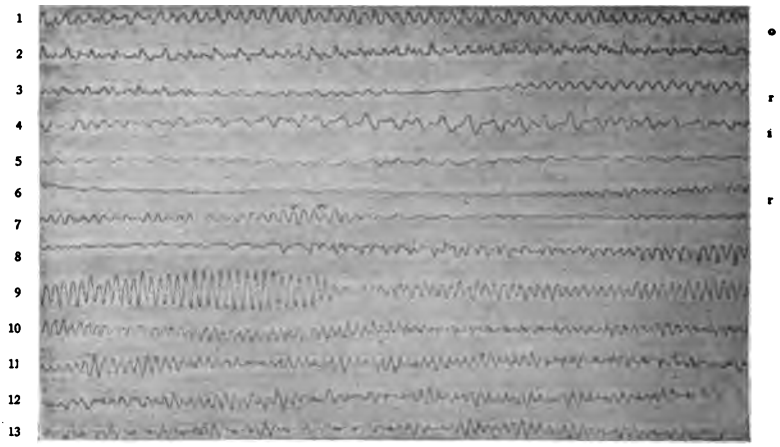


PLATE VIII

This plate concludes the word "morir."

Plate VIII. The first two and a half lines of this plate belong to the vowel "o." The "r" appears as a singular interruption in the middle of the third line. The vowel "i" extends through the fifth line. The next line records the final "r."

Notes on Voice-Waves

The voice consists of the tone from the glottis modified by resonating cavities above and below it.

This tone, "the laryngeal tone," is produced by the closure of the vocal lips across an air passage from the lungs. The vocal lips are composed of two muscles, namely, the thyro-arytenoid (externus) and the vocali (usually called the vocal cords). The muscles on each side form a triangular mass of flesh which in no way bears any resemblance to a cord or membrane. It cannot possibly vibrate like a cord or membrane. It vibrates by compression, yielding sidewise to emit puffs of air.. This has been directly observed by Musehold and Rothi with the laryngostroboscope.

The glottis vibrating in this way emits a series of puffs of air of the same nature as those emitted by a tube opened and shut rapidly, as in the case of the well-known instrument, the "siren," which is a disc with a number of holes rotating in a tube. These puffs of air are of the nature of a sudden compression with succeeding vibrations of lessening strength. The musical character of a singer's laryngeal tone depends upon the form of these vibrations. These forms depend in turn upon the manner in which the vocal lips vibrate. In a voice where there is a good musical quality these vibrations have a form that impresses the ear pleasantly. Every change in the vocal muscle or the thyro-arytenoid muscle will produce a difference in the form of the puff and consequently in the musical quality. Since the muscles of the vocal lips are a part of the musical apparatus of the larynx, their activity and adjustment will depend not only on the way in which they themselves are innervated, but also on the adjustment of the surrounding intrinsic or extrinsic muscles of the larynx.

The character of the vibrations from the larynx is modified by the complicated resonance cavities of the pharynx, mouth, and nose, and by the chest cavity. The modification occurs according to the law governing the action of resonating cavities with soft and semi-soft walls.

The resulting tone, as it issues from the mouth, consists of vibrations produced in the way just described. On the phonograph or the gramophone it can be studied by the careful methods devised by Professor Hermann and myself.[1]

A series of such curves of the voice of Caruso is presented above.

When such a curve of the voice lies before us, we can do several things. In the first place we can analyze it into a series of curves with the wave lengths in the relation 1, 2, 3, 4, etc., but with different amplitudes; such a series is called a "harmonic series." We thus get a kind of equation for the original curve in a series of arbitrary quantities. We can do just the same thing with a straight line or point, or a profile of a face, or part of a person's signature. From the results we can even reconstruct the original curve. This analysis—called a "Fourrier analysis"—is a perfectly arbitrary one. It does not represent in the least the manner in which the original curve was produced by vibrating bodies or cavities. From a Fourrier analysis we can reconstruct an arbitrary straight line or a signature, but this does not imply that the straight line or the signature was produced by a harmonic series. We can analyze and reconstruct a voice curve in the same way, but it is quite absurd to suppose that this analysis has anything to do with the way in which the voice vibration was actually produced.

On the other hand, we can analyze a voice curve in quite a different way. We can analyze the voice curve into a series of elements that would conform to the known laws of vibratory masses of muscles like those of the vocal lips and of resonant soft walls like those of the larynx, the floor of the mouth, and the cheeks, and with semi-soft

[1] The author's description of vocal-cord action and the formation of the vocal cyclone differs from all other authorities, as seen in preceding chapters.

walls like the hard palate. The method involves an immense amount of work for each wave of the voice, but its results are not arbitrary mathematical formulas with no physical meaning, but are definitely established facts concerning the nature of the tone of the voice and the manner in which it is produced.

The results that have been established by these methods prove that the vibration of the voice has not the slightest resemblance to a combination of a series of tuning-fork vibrations, as was supposed by Helmholtz. Helmholtz's theory served its purpose in stimulating research work, but has now been abandoned by all the prominent investigators.

An important deduction from the newer work is found in the emphasis to be laid on the proper action of the muscles of the larynx in order to produce a good tone. If the original vibration from the glottis is not good, no amount of modification of the vibration can make it so.

ADDENDA

The papers that follow are given here, not always as confirming my views, for they differ more than once, but as showing how others have been seeking for the solution of a problem, which can be solved only as I have been the first to solve it, by a complete demonstration of the function of Art and the function of Science, in that perfect union of the two, which I have denominated "Vocal Art-Science."

Fatigue of the Voice—Phonesthenia.

This term is analogous to the better known term "Neurasthenia." It was first treated of by Flatau, in his celebrated article, "The Functional Fatigue of the Voice, in Singers, Speakers, and Commanders" (1906). He was the first to define the symptoms, and to offer an effective means of treatment, of this affliction. Other authors on the same subject are Barth, Gutzmann, Labeus, Kassel, Hullah, Michael, Gerhardt, Storch, Mackenzie, Fränkel, Kraus, Avellis, Hermann, Spiess, Lerin, and others. Dr. R. Imhofer, of Würzburg, has written a most interesting and comprehensive book on the subject of "The Fatigue of the Voice."

Avellis divides fatigue of the voice into two classes: organic and functional; the former resulting from a diseased condition of the organs which are involved in voice-production; the latter from improper use of the voice, and in which there is no organic disease. Phonesthenia, therefore, belongs to functional derangement. In "Vocal Art-Science" only normal voice-organs (so far as their organic structure and nutrition are concerned) may be considered as available for development to artistic excellence, and therefore Phonesthenia is to be taken into account; while such "fatigue" as may result from disease, is a question for the laryngologist, rather than for the vocal teacher. (See Chapter XV.) "Voice-using is hygienic. The vocal organs are by nature strong, the folds themselves being, perhaps, the strongest organs in the body. Proper use adds to their strength, while acting as a body-cleanser and vitalizer, a builder of tissues. Faulty methods tend to produce venous congestion, starve tissues and poison them." To this might have been added, that fatigue of voice quickly appears from improper vocalization. Mosso says: "Fatigue consists (1) of a physical fact which we can measure and compare, and (2) a psychic moment, which is impossible to measure and compare."—Imhofer, in the work cited, says: "Without any pain, a peculiar feeling appears in the larynx, called in psychology 'feeling of dislike,' and *this is the first subjective symptom* of approaching fatigue of the voice." "Psychology" is correct, since you cannot feel a dislike physiologically.

Reciprocal Functional Relation of the Laryngeal Muscles.

The crico-thyroideus

Prof. M. Grossmann, of Vienna, in "Contributions to the Doctrine of the Laryngeal Muscles," ("Archiv f. Laryngologie u. Rhinologie," Vol. XVIII, p. 463 *et seq.*). "The crico-thyroid extends the vocal cords from front backwards, the cords changing from the angular position of rest into a linear position; the contraction of the muscle causing extension, as well as adduction (approach) of the vocal cords. . . . By contraction of the crico-thyroid, the anterior narrow part of the cricoid cartilage is moved toward the thyroid cartilage; by the contraction of the vocal-cord muscles, the

opposite effect is produced. For this function, therefore, these two muscles do not work in an alternating, but an antagnostic manner."

Drs. Moeller and Fischer, Copenhagen (Arch. f. Laryng. u. Rhin., Vol. XV):

"It seems that for the functions of the crico-thyroid and the vocal-cord muscles, there is no unity of opinion. All authors agree that *they are* the proper voice-producing muscles; but while some are of the opinion that the crico-thyroid regulates pitch by its contractions, others attribute this function to the thyro-arytenoid (internal). There is, however, no difference of opinion regarding the fact that the crico-thyroid moves the cricoid cartilages or arytenoids towards each other."—Ewald says that the alteration in size of the interspace between the two cartilages is too small to explain the wide extension of tone-register of the human voice. . . .

"With the help of the x-ray, it has been ascertained that the higher the tone, the narrower the interspace between the cricoid and thyroid cartilages becomes; but the climax is not quite regular. The narrowing of the interspace is a consequence of the ascending motion of the cricoid cartilage."

Dr. Jellenffy, Pesth, "The Musc. Cricothyroideus" (Pflueger's Arch. f. d. ges. Physiol., Vol. VII, 1873):—"The crico-thyroid is the tensor muscle of the vocal cords. This is the general opinion." On the ground of extensive experiments, this author found:

(1) In scale-singing, the larynx is continuously raised with the continuously ascending pitch; higher and higher till, with the highest head-tones, which become already quite thin, it touches the convexity of the upper rim of the thyroid, and the lower edge of the hyoid bone. Up to this they are separated by a narrow distance.
(2) The angle of the thyroid diminishes with the ascension of the tones, and grows with their descent.
(3) With the rise in pitch of tone, the arch of the cricoid rises higher and higher to the thyroid; the distance separating it from the lower edge of this cartilage diminishes more and more, but grows in the opposite case.
(4) The arch of the cricoid moves with ascending pitch, not only upwards, but is also pulled backwards; its frontal point removes from the frontal surface, and draws near the spine. With the descent of the tones, it takes its former position.
(5) The diameter of the trachea appears larger with the deeper, and smaller with the higher tones. . . . These are empiric facts.

The crico-thyroid muscle, whose functions are probably the most complicated of any in the human body, has three offices, of which (*a*) one acts in a vertical direction; (*b*) one in a horizontal plane from before backwards; (*c*) one acts in a horizontal direction from right to left.

These three act so much as *individual* forces, that it is impossible to consider the functions of the crico-thyroid as a unit. Moreover, the author finds that the cricoid is *raised* towards the lower edge of the thyroid, and not the latter *pulled down*. In this way the plate of the cricoid is bent over backwards, and the points of insertion of the vocal cords removed from each other. This is a moment of *passive tension* in the mechanism of the vocal cords; also, the conoid ligament is relaxed and moved from the previous *vertical* into a more *horizontal* position. This alone causes the rise of the cricoid. . . . That force which acts in a horizontal plane in the front to back direction, pulls the thyroid *forwards*, and, at the same time, the cricoid *backwards*, and thus strains the vocal cords in a direct way. . . . Having reached a limit beyond which it can not go, the muscle has now to fix these cartilages into the already gained position, one against the other. A jerking of the ligaments is prevented by the inferior constrictor of the pharynx, which is attached to both sides of the thyroid at its posterior edges and outer surface, and makes impossible, by the same contraction, a farther forward

motion, as well as too wide backward motion of the cricoid. The inferior constrictor of the pharynx, is the perfect antagonist of this force of the crico-thyroid, which has no movable point of insertion, but only two extreme points. . . . The third action of the crico-thyroid muscle, which takes place from right to left in a horizontal plane, is to *pull inward.* It is mighty in all its fibres, especially in those which insert at the inner surface of the thyroid. This force has its fixed origin at the cricoid, for, since the latter is pulled by the muscle of one side in one and by the muscle of the other side in the opposite direction, it naturally remains (among the three offices of the crico-thyroid) stationary, and presents for the forces of both sides, fixed points of origin, while its movable point of insertion is at the thyroid.

When the thyroid cartilage, fixed by the thyro-hyoid muscle, becomes immovable for the fore-and-back action; no force exists which would pull the plates outwards, and by this, the function of the force in question would be annulled. Therefore, the latter may act undisturbed, bringing the plates of the thyroid nearer to each other, for the following purposes:

The two elastic plates of the thyroid form an arch, which, for the low tones, becomes flattened to almost a semicircle. When the tones rise, the crico-thyroid muscle, with its three offices, goes into action. By drawing the plates toward each other, they flatten its wings more and more and give them a straightened direction, by which they require less space in the right-to-left, than in the fore-and-back, direction. This can have only one effect: the angle of the thyroid moves farther forward from the posterior wall of the larynx, separates the anterior insertions of the vocal cords from the posterior ones—stretches the vocal cords. . . . Therefore, it is quite correct to call the crico-thyroid muscle the tensor of the vocal cords; but its function is different from the generally accepted one. For, by one and the same muscle, the vocal cords are stretched in a *triple* manner, inasmuch as their points of movable insertion are separated from each other:

(a) By the bending over of the cricoid backwards (the function of the vertical force);
(b) By the mutual separation of the cricoid and thyroid from each other in a horizontal plane in the fore-and-back direction (the second office of the muscle);
(c) By forward motion of the angle of the thyroid cartilage (the third office mentioned).

If the above be true, then an assistance to, or hampering of, the different offices of the crico-thyroid action, should result in a rise or descent of the tone. Jellanffy made the following tests:

(a) In a long-sustained tone, the lifting of the cricoid with the finger-tip will always cause the tone to ascend; and if this is repeated at short intervals, a trill is produced, the fundamental tone of which is the deeper one. *Thus, a rise of the tone was produced by increasing the effect of the vertical force.* By pushing *down* the cricoid (which is somewhat difficult to perform) the finest trills with higher fundamental tones can be produced; *through weakening of the vertical force of the crico-thyroid muscle the tone is made deeper.*
(b) If a tone is struck, and a finger is put on the anterior surface of the cricoid-arch, the tone is raised almost with the touch. The pitch of both tones is raised with increased pressure. If the pressure is rapidly intermittent, a trill with deep fundamental tone results; *again a rise of the tone, but this time by helping the front-and-backward force.*
(c) If a tone is sustained and the outer surfaces of the cricoid-plates are, on both sides, pressed with two fingers, the slighest pressure will raise the tone, and a trill with a deeper fundamental tone will be produced, in the way shown above; frontal,.in this case, by narrowing the angle of the thyroid—*i. e.*, by strengthening the right-to-left force.

Prof. A. Jurasz, Heidelberg (Arch. f. Laryngol, u. Rhin., Vol. XII, 1901), agrees with "most authors" that the principal function of the crico-thyroid muscles is "to bring the cricoid and thyroid cartilages nearer together, whereby the vocal cords are stretched."

Vowel and Register Question

A contribution to the subject by Dr. Th. E. ter Kuile, Amsterdam. (Pflueger's Archiv. f. d. ges. Physiol., Vol. CLIII, 1913.) If an Edelmann C-fork is brought into vibration, and its tip placed loosely in contact with a piece of cardboard, or wood, a remarkably vowel-like sound will result. The author took small cardboard boxes and pasted a piece of cork on the bottom, outside. The vibrating fork was then placed against the cork, when a clear vowel "Ah" was heard; the same with different pitches when different forks were used. The vowel U (OO) could be produced only when the clang-box (a larger one with smaller opening than for A) was pressed against the fork near its handle. Between these *extremes* lie all modulations, and they can be produced with the same box, by motion of the fork. . . . The production of certain vowels depends on the areas and quality of the bottom, and on the size and form of the box. The areas of the boxes equal those of the pharyngo-oràl cavities; although he found this to be so, empirically.

As to the question of what parts the vocal clangs (which are heard at a single stroke of the vocal clang-body) consist, the author could ascertain, with his apparatus: That it is sometimes difficult to say just what *tone* a certain vocal-clang-body will give; or, in other words, the vocal body produces no *musical* clangs, but only *noises*, because in them a *definite pitch* is hard to discern. This is made somewhat easier when different clang-bodies are struck successively; then the pitches can be more easily recognized. It is wrong to think that a clang-body, which gives a good vowel, permits its pitch at a stroke to be easily recognized. On the contrary, a *clang-body* which produces an uncertainty as to pitch—even to the extent that the *exact* pitch is a matter of doubt—yet, a splendid vowel may result from a quick periodically induced frequency of any fundamental tone.—Later, this author used, instead of a fork, an electric hammer, which, vibrating by an alternate current, struck the clang-body in the frequency of the polar-change of this current. On this principle the author constructed a vowel apparatus, with which he can produce clearly some eight vowel-effects, while the modulations between can be easily arranged. Although the apparatus works without air, the imitation of the vowels is so astonishing, that this way of vowel-production, so different in principle from the physiological formation, suggests important conclusions regarding the theory of vowel-production.

Where the timbre of the vowel is dependent on the hardness of the hammer, there must be, besides the inherent tone-region of the clang-body, *another momentum* of importance in vowel-formation. Hard hammers can, on the one hand, possibly help, in a way, the production of higher accessory tones, but, on the other hand, they may directly influence the timbre by a sudden stroke of the hammer upon the clang-body, or a sudden rise of the clang-curve, at every stroke. This the author calls *acuity* (sharpness). . . . He arrives at three elements in vowel-formation: The approximate pitch of the vocal sound; the quick ring-off; and the accurately given inherent tone-pitch, through the damping of the clang-body, the sudden beginning to sound by acuity. . . . If the vowels are arranged horizontally (in a diagram) by acuity, and vertically according to pitch of the inherent-tone, then the so-called vocal-triangle originates automatically. It is the seven-vowel figure of Du Bois Raymond:

e-i
a—ö-ü
o-u

Phaenomenology—Positions and Motions of the Larynx in Relation to Other Organs of Voice and Speech; Articulation.

With open mouth, closed mouth, chest-tone, chest-register, timbres, tables and measurements of different phonic positions of the larynx: straw-bass, falsetto, crying (shouting), tone-degrees by means of ascent and descent of the larynx and fixed larynx.—Merkel: Anatomy and Physiology of the Human Organs of Voice and Speech, 1857.

Very rare are the cases where the phonic activity of the larynx could be observed in the living body. Bell, Bickert, Dunglison, Malgaigne, Stilling, and other observers have noted, in the cadaver, how the glottis was dilated at inspiration (artificial, of course) and was compressed at expiration. Magendie has experimented with living animals, laying open the glottis, and saw that voice was produced by vibration of the vocal cords towards each other. From all this we learn that in life the voice is produced by the same organs by which tone is produced in an extirpated larynx. . . . The position of the larynx in the middle of the neck during toneless respiration is not perceptibly altered. During deep, forced inspiration it descends, because the trachea is dilated and hereby also shortens, while at retarded expiration (with compressed glottis—as in vocalization) the larynx rises proportionately (though the trachea is apparently elongated in consequence of its compression). . . . . The 'Throat Region' in Man is bounded by the mastoid processes of the temporal bone; by the entire lower ridge of the lower jaw; by the upper ridge of the 'handle' of the sternum (breast-bone); and the larger part of both collar-bones (clavicles). . . . The lower ridge of the jaw and the two sterno-cleido-mastoid muscles form a triangle, the base of which is directed upwards and its apex downwards—the 'large throat-triangle.' The organs of voice—phonation—are located about the middle of this space, or area. . . . The position which the larynx holds is quiet and indifferent—the 'static zero-point' of the larynx—the index of which is the most prominent point of the thyroid cartilage. . . . On opening the mouth, the larynx descends a little, and when the mouth is opened wider, as at yawning, the larynx descends so far that the lower edge of the cricoid cartilage and the sternal edge are on the same level. . . . These motions of the larynx, without tone-production, must be taken in close consideration, if one wants to be in position to understand correctly its motions with the tone-phenomena. . . . An important function of the human neck is to provide a *free traveling space* for the larynx. . . . At deep inspiration, and at production of the deepest natural tones, the larynx descends so deep, that even of the cricoid arch nothing can be felt; and at swallowing, it ascends so high, that the Pomum Adami (Adam's apple) disappears behind the throat fold, which makes room for free play of about two inches, or an elevation and depression of one inch from the zero-point, in both directions. If we consider that the entire trachea, in a state of relaxation, is only about four inches long, this enormous movability would be incomprehensible, but for the fact that besides the trachea, both bronchi also permit a comparative extension; leaving apart the influence, which *nivean* changes of the diaphragm, under certain conditions, may have on the trachea. Considering further the great difference in the length of the neck in different individuals, the big difference in the play-space of the larynx becomes apparent, also the importance which the length of neck in a person has for phonic abilities. In a long neck, the larynx transcends its zero point farther than in a short neck. Now, since the up and down motion of the larynx is a means of tone-graduation, an individual with a long neck has, other things being equal, the facilities for greater tone-graduation than a person with a short neck. . . . The *phonic* position

of the larynx follows the phonic width of the glottis, and the number of vibrations of the intended tone; its height is in general, and with the same register, in straight proportion to the height or to the number of vibrations of the tone. . . . The *aeric* position of the larynx is determined, in the first place, by the quantity and tension of the inspired air moving towards the glottis. The deeper the inspiration for a scale requiring much air-tension, the deeper the larynx drops, regardless as to whether the first tone to be produced is a deep or high one. On the other hand, the more air, during phonation, has been used up and the more the tension sinks, the more the larynx rises, even if the number of vibrations of tone to be produced diminishes in this respect; therefore the *aeric standpoint is independent of the phonic*. . . . The aeric position of the larynx seems in the first place to be determined by the position of the diaphragm, which, at deep inspiration, also drops, and at expiration rises. The aeric position must, if possible, be measured; starting from the palatal vault, because the sternum is always considerably lifted with this phenomenon, when the inspiration is a deep one. With the gradually leaving air, it naturally drops back to its zero or point of indifference, and sometimes beyond it. . . . Finally, the position of the larynx at the neck is, regardless as to height or depth, more or less *lax* or *fixed*; that is, the larynx can be either easily or hardly moved laterally from the median line of the neck. This grade of fixation of the larynx stands in general in straight proportion with the grade of the tension of the expirative air-column, while it is to a large extent, independent, from the position of the larynx. However, in general, high fixation-grades coincide with a deep position of the larynx, because every copious activity of the muscles of the neck requires a large volume of intonation-air, at the taking in of which the larynx has always a deep position. . . .

Experiments with living organs of voice—Tones with closed mouth; chest-tones.

If a *deep* tone, possibly near the phonic zero-point, is produced *very piano* with closed mouth and the usual respiratory action, the following can be noticed:

The larynx, in the first place (the Pomum Adami, which we shall always take as index), receives at intonation a sudden small push (jerk) upwards and a little forward, without changing, to any extent, its static zero-point. Both wings of the thyroid cartilage appear a little drawn to each other. During the sounding, the covering of the excisura thyroidea becomes a little inflated and transmits to the touching finger the vibrations of the striking air-columns. The hyoid retains its median position towards the pomum; the latter advancing a little toward the former when tone is sustained. The larynx remains relaxed. Such a tone as, for instance, "As," which means, in English, A-flat, could not be sustained longer than 10 or 12 seconds. If from this tone, at an equal tension of air and a new (not deeper) inspiration, a gradual ascension of one octave in about two seconds' time is made, the pomum also gradually ascends (about from 2 to 3 lines) and at the same time a little forward. . . . The elevation of the thyroid cartilage and the whole larynx is effected by the musculus hyothyreoideus. . . .

Tones with mouth open—Chest-tones; chest-register.

The mechanism at the production of a tone with an open mouth, shows various differences from that at the production with a closed mouth. At a sharp, distinct intonation, the expiration is, for a moment, disrupted; that is, the glottis is closed, followed immediately by the vibration of the vocal cords. This closure of the larynx is not an absolute necessity for phonation, for this closure can not only be continued at liberty before the tone

follows, but the glottis can also be closed without a tone following its reopening; closing the larynx and stopping the breath are not one and the same thing. The glottis may be closed several times during one and the same expiration, while breathing ceases after a completed inspiration before one expires, whereby one may at will close the glottis, or leave it open. The position of the larynx, át and for this closure of the glottis, depends on whether an intonation is intended or not. If, with a moderately opened mouth, as an experiment, the glottis is closed, the larynx, as a rule, moves a little upward. If this is repeated several times during one breath, the larynx takes, for every new closure of the glottis, a higher position than the preceding one. . . . If, however, the glottis is closed earnestly for the purpose of producing a real tone of a certain number of vibrations, the larynx is already previously put in the neck-zone requisite for the intended height and column of the tone, and in the movement of the closure of the glottis, the larynx receives a little jerk upwards, and as soon as phonation starts forward, remains in this position as long as no alterations in the mechanism occur. If the closure of the glottis is quick and energetic, the tone must be, at least for the first moments, also strong—this process being indicated, in music, by the sign > over the respective note.

While for the production of a dark timbre, the larynx generally has a deep position, its position for a light timbre is higher. For the deepest chest-tone, the position of the larynx is a little below zero; then it rises with the tone gradually, and reaches, with the highest chest-note, the jaw; making, at the same time, a distinct 'lever motion.' The higher position of the larynx corresponds with the phonic zero-point of the light timbre (*timbre clair*). The latter lies about 4-5 grades above the dark timbre. For example, if the phonic zero-point of the latter rests on H(B natural), this point of the light timbre rests about on F. Further, while the static zero-point of the larynx rests on D (*piano*) with dark timbre, for light timbre it is on G.

Falsetto-Register

The volume and area of the falsetto is as large as of the chest-register, reaching about d^1 to c^2-f^2; it lies about an octave above the chest-register. Women have a deeper falsetto than men. Falsetto is the common sound of speech in children. If we compare the path of the free, movable, non-fixed larynx of the chest-register with the falsetto-register, we shall find that the path of this organ with the falsetto is generally only half as long as with the chest-voice, comprising exactly the upper half, lying above zero; that the larynx in general, for the falsetto-tones, is less movable than for chest-tones; that the height of the larynx position does not depend on the number of vibrations, as the highest falsetto-tone (the amount of vibrations being doubled) does not require a higher larynx-position than the highest chest-tone; that the deepest falsetto, with regard to its mechanism as well as to its larynx-position, agrees with the equivalent chest-tone, produced *pianissimo;* while from this point on the difference of both registers becomes noticeable gradually and in rising progression, until after reaching the last or highest amphoteric tone, the falsetto-register becomes *individual* and shows, from this point on, its characteristics clearest. . . .

At the highest falsetto-tones, the lower pit of the throat is very deeply contracted inwards, the trachea with the cricoid backwards; the slit becoming very narrow; the pomum, however, is still a little projecting. *At the highest chest-tones*, the lower pit of the throat is not very much deepened, but the levator muscles are very much exerted; the outer compressor muscles only in proportion to the fullness of tone. The more *piano* the tone, the higher the position of the larynx, although the exertions of the muscles are the same (equal). With interspersed deep tones, the larynx drops in very marked steps, and rises directly for new high tones. . . .

Throat-Voice

Older scientists and teachers of singing declare the throat-voice (*voce di testa*), and falsetto, to be one and the same. Later a distinction was made. Some consider the throat-voice a variety of the chest-voice; others, as a higher falsetto; still others think that the throat-tones are the highest chest-tones, produced by a special muscle mechanism. *The truth is that not all singers possess this register.* Merkel is of the opinion that throat-voice *is nothing else than a continuation of the chest-voice upwards, produced by a mechanism, which seems to require only a little tension of the air-column, and no special tension of the cords.* The larynx is *fixed* in a median position in the throat. The throat-voice serves to intone high chest-tones *piano*. Hereby the larynx does not descend so deep as when the same tones are intoned *forte*; the lateral throat muscles being somewhat contracted.

The throat-basso register is to be distinguished from the *straw-basso*; the mechanism being a different one. The position of the larynx is a little higher than with the straw-basso, but it stands not over zero from the sternum. With regard to the cavity of the mouth, it is higher than to be expected at this degree of the scale. Only at a fine disposition of the larynx is this register pleasant and may be used in chorus singing. In general all theories referring to this register are unclear.

Straw-basso Register

The principal elements of this register are the following: The larynx takes a position in the throat higher than that which is required to produce the same tone with the chest mechanism. Generally the position is a medium one around the static zero-point. The downward motion of the larynx at deepening of these tones, is by far not so remarkable as, other things being equal, with the chest-register. With the straw-basso the descent of the larynx seems not to be a means for deepening the tone; it even happens that the larynx may somewhat rise when such deep tone is forced. The muscular action is, in general, less with the straw-basso than at the production of the next highest chest-tones (deepest basso tones). The hyoid is, the deeper the tone, the closer drawn to the thyroid cartilage, while the levator muscles, especially the geio-hyoids, seem not to be specially contracted. In general, the throat shows very little deviation from the state of indifference. The glottis narrows down, the more so the deeper the tone. The production of tone ceases when the glottis is so narrow as to exclude breathing; the deeper the tone, the emptier and more reduced it becomes. . . . For the intonation of the straw-basso requires very little air; a straw-basso can be sustained ad libitum without renewed inspiration. In this regard the straw-basso has some similarity with the falsetto-register. The highest falsettos are as thin and small as the deepest straw-basso tones.

The Ontogenetic Development of the Voice

By Dr. Ernst Barth (Einführung in die Physiol., Pathol. u. Hyg. der menschlichen Stimme. 1912).

The Voice of the Infant. The voice of the new-born infant is not an expression of physical mood (as claimed by the old schools and philosophers), but purely a respiratory reflex. If respiration, which starts with the entry into life, can develop *without* the cry, the latter (the cry—that is, the expiration overcoming the closed glottis) will cause a more effective inflation of the lungs, than if the expiratory air escapes without the resistance of the sounding glottis. The cry of the new-born has, therefore, not the character of an emotional expression, *but is the physiological expedient which inflates the air-passages of the lungs, and facilitates expiration.* . . . Up to the fifth week,

the cry of the newly-born remains a reflectory modification of respiration, which has nothing to do with emotion. From this time on, the cry may be expressive of discomfort; but also a sense of pleasure—the babbling. At first the babbling is also a "cry," but it is more a *singing* cry in which the softer vowel-sounds predominate. At the age of seven or eight weeks, it can be clearly and with regularity observed that soft vowel-intonation expresses pleasure; while the hard intonation may be considered as expressive of displeasure. . . .

The Development of Speech appears independent of the development of voice. The originally *accidental* expressions of pleasure, in the babbling, are now *voluntarily* reproduced, as their hearing and repetition sustain the feeling of pleasure. With the voluntary babbling, imitations of acoustic impressions become associated—the imitation of its own babbling as well as of other sounds. With the hard and reproduced vocal sound, conceptions become associated: mama—papa (the first articulated syllables) become the expressions for mother and father. The articulated *vocal sounds* become *acoustic signs* for a person, an object, or, in short, the sum of associations, forming at the conception of this person or object. *Voice becomes speech!*

The Break or Change of Voice at Puberty (*Mutation*). With the general bodily development of an individual corresponds the development of the voice. But in children it is followed by a phase of development (puberty) which means more than simple growth. The change into puberty carries along the "break" of voice—mutation. It begins in boys with the 14th or 15th year. This functional change of the voice is accompanied by certain *anatomical changes* in the larynx. The vocal cords show an *extraordinary growth in length, breadth, and thickness*, which explains the changes in the column as well as in the "color" of the voice. This growth causes increased blood-supply, a certain *physiological* inflammation, which makes a special care of the organ necessary.

The vocal cords increase by about *one-half* in size. At the same time an increased growth of the larnygeal cartilage takes place. In the thirteenth year of age, the average height of the angle of the thryoid cartilage is 12 to 13 millimetres. After mutation, it is about 20 millimetres. The lateral wings of the cartilage have a horizontal breadth, at thirteen years, of 25 mm.; after mutation, about 35 mm. All other laryngeal cartilages show corresponding increased growth, and the Pomum Adami appears. On account of this increased growth in the structural dimensions of the larynx, the musculature is not yet quite strong enough for all the strain required. The vocal muscles give out at the production of chest-tones, and the voice "jumps" into falsetto. . . . While the increased growth of the larynx is completed in six to twelve months, the development of the muscles requires much more time, and therefore, professional singing should not commence much before three or four years *after* the completion of the mutation. Hemorrhages, atrophy, dilation of the joints, may cause a complete wreckage of the fine mechanism of the larynx and the voice.

In girls, the *change of voice* occurs earlier and quicker, but in a much less remarkable degree as regards the larynx, which grows only somewhat in the vertical diameter, while the fore-and-back and the right-to-left diameters hardly increase at all. From an accurate study of the measurements of the cords in girls and boys, the general conclusion is drawn, that after puberty the ratio is 2 for girls, 3 for boys. It is not true that a soprano in a boy necessarily yields a basso or baritone, after puberty; and an alto a tenor.

The Voice of the Grown Person. After puberty, different changes take place in woman, up to the 30th year, and in men up to the 36th to 38th year (in power, volume, color, beauty). Peculiarities of voice and similarity of color are hereditary to a certain extent.

Although every voice has its individual character, musical art has fixed, for both sexes, three categories of voice, with reference to volume and color: low, middle and high. (In man, basso, baritone, tenor. In woman, alto, mezzo-soprano, soprano.) . . . .

The average range of a mature human voice is about *two octaves*, in both sexes. Generally, the female voice is one octave higher than the male. Consequently, the "orchestra" of the human voice is *four octaves*. There are exceptions: The D of the basso (in oratorios and Mozart operas) has 74.25 vibrations; the f^3 (Zauberflöte) has 1408 vibrations. These are extremes, as are the deepest faultless tones observed, namely, FF, contra-octave (44 vibrations) in the basso, Fischer (eighteenth century), and, as the highest, the d^4 (1183 vibrations) of Lucrezia Ajugari (1770), confirmed by Mozart.

The covering of tone, as disclosed in an x-ray picture

Dr. R. Schilling, (in the "Archiv. f. Exper. u. Klin. Phonetik," Bd. I. H. 2) says:

Manuel Garcia detected certain differences in the timbre, or clang, of the voice, resulting from a certain position of the epiglottis, producing what is termed "covering"—the tone is veiled, suppressed, with the lifted epiglottis; while, when the epiglottis is lowered, the tone is brilliant.

In Dr. Schilling's work, "The Mechanism of Covering The Tone" (1911), he claims to have proved that the theory of the lowering of the epiglottis, in producing the "covering" effect, is not correct. He experimented with five vocal artists. He found that, with the vowels Ah and Aw, there was always a lifting of the epiglottis in all registers, especially centrally. With the other vowels, results were not clear. He affirms that "covering" has to be considered from an esthetic and pedagogic standpoint. The uncovered tones of an untrained, or hardly trained, voice, upwards from a certain point, will show a flat, vulgar clang, lacking in noble quality. . . .

There is in existence a detailed description, by Gutzmann, of clang, which shows that, with covered tones, certain constant differences exist in the amplitude relationship of the partial tones; relative strength of the fundamental tone with the covered tone; of the partial tone with uncovered tones. Also, further results show the relation of the covering to vocality; beginning with a certain tone, most vowels retain their vocality when the tone is covered. Furthermore, the arytenoid cartilages are, at the transition from open to covered tonality, lifted backwards, and therefore appear narrowed and the longitudinal extent of the vocal cords enlarged. The false cords, with covered tonality, move somewhat outwards, so that the true cords appear, with the open tone, somewhat narrower than with the covered. The laryngoscope and endoscope yielded incomplete and unsatisfactory results; therefore x-ray pictures (instantaneous pictures of 1-100 seconds duration) focus plate at a distance of 60 centimetres, plate kept parallel to median plane of head close to it—head not fixed—were tried. (*Note.* "Closed" and "open" refer to the *vocal* character of two different vowels; while "covered" and "uncovered" refer to the *clang* or *color differences* of one and the same vowel, which can be produced with closed as well as open vowels.)

The skiagrams (x-ray pictures) secured by Schilling, show decided alterations in the laryngeal space (that is, the full space from the glottis upward to the pharyngo-oral space); and it is divided into two apartments: An anterior, between the epiglottis and the area in front of it; a posterior, measured by the distance from the epiglottis and the posterior wall of the pharynx. This entire space, so difficult of laryngoscopic examination, has been made a special study by Barth, Grunmach and Scheier; and it was found that this space changes according to register, pitch and strength of tone, and according to the vowels. In all cases they found the space was smallest with A(Ah) and largest with the English EE. With the vowel A(Ah) the laryngeal space was enlarged at the covered tonality, and the epiglottis erect. The border line of the base of the tongue forms, at covering, a more bent curve. It bends especially at the root of the tongue, into the glosso-epiglottidean space. The larynx in general stands deeper with covered

tonality. In this lowering, of course, the hyoid bone moves downward and a little forward. The vertical distance of the hyoid-body from the hard palate, in three cases examined, was about one centimetre larger than with the uncovered tone. The line of the floor of the mouth, at covering, is always a little lowered. . . . The soft palate is lifted higher at covered than at uncovered tonality, its border stretching more upward into naso-pharynx. . . . Referring to other vowels, it is noted that, as a matter of fact, the laryngeal space is wider, proportionately, than with Ah. Therefore, the difference in width of this space will, with these other vowels, be actually smaller. . . . The descent of the larynx is expressed most strongly with Ah and Aw; less with the other vowels; and not at all with Ü (German *umlaut*). The soft palate, where recognized in the pictures, is, at covering, clearly elevated. . . . In the maxillary opening in general not much difference was found. With closed EE, O and OO (U) it was at covering a little wider. . . . The opening of the lips (measured in its vertical diameter) is always somewhat smaller with covered tonality; the lips being (in the horizontal diameter) more protruded. . . . The difference, compared with uncovered tonality, is especially clear with the closed EE (German IE). Therefore he avers, that with "the vowels with an *eo ipso* wider laryngeal space and erect epiglottis, the alteration in the laryngeal space, at covering, is comparatively small. Nevertheless, the author believes that the dilatation of the laryngeal space is characteristic of the covering position, as it appears strongest with those vowels which possess, with respect to clang, the strongest covering differences. . . . In the covering adjustment, in the region of the laryngeal space, three principal alterations participate: (a) descent of the larynx, (b) erection of the epiglottis, and (c) enlarging of the glosso-epiglottidean space. In general the laryngeal space is dilated both in a vertical and horizontal direction. . . . With the hyoid, the thyroid cartilage moves downwards, but not always to the same extent. . . . It is of importance to ascertain whether the motions of the epiglottis (at covering) are purely passive, caused by the displacement of the neighboring organs, or whether they are active. Barth says the epiglottis is erected passively by the removal of the thyroid from the hyoid, and the ensuing tension of the thyreo-epiglottic ligaments and the hyothyroideus, when other tensile forces are not influencing it. . . . Eijkman says: The inclination of the epiglottis is influenced by the distance between hyoid and thryoid. That is, if they are wide apart, the epiglottis is straight, erect; if approaching, it inclines. . . . The phenomena at covering, as revealed by the skiagrams, are based on a sum of single coördinate motions partly produced by nature, partly by the practice of the singer, and then combined by him for his purposes to a general coördination. The covered tone is darker. . . with simple tones, the higher is always brighter. . . . Liebermann says: The hypothesis is, that the "brightness" (Helligkeit) of the clang is determined by the brightness of the partial tones in such a way that each partial tone contributes, in accordance with its intensity, to the total brightness. From this it follows that the covered tone must sound darker than the un-uncovered. Now, just as each partial tone of the clang has its brightness, it has also its vocality, and the "vocality of the *total* clang is again determined by the *partial* intensity; this explains why a clang changes, with an alteration in structure, its vocality also." Pielke contends that, in the high pitches of the voice, most vowels can be produced correctly with covered tonality. If a scale is sung upwards uncovered, then, he says, every vowel is subject (from a certain limit on) to alterations. Schilling's experiments (with the x-ray) gave different results; so that he affirms Pielke's contention would be changed to: The vocal character is easier to retain with covered tonality, than with uncovered.

Electro-magnetic tone-treatment as cure for the Voice

Professor Flatau, Berlin ("Die Stimme"), describes a method of "treating" the voice by electro-magnetic tone-treatment. In the Berlin Klin.

Woch., No. 27, this method is described in detail. He claims to have produced excellent results in the treatment of functional disturbances. . . .

"Phonic compensations, perceivable disturbances of intonation can be made to disappear by certain influences. . . . The most important compensation appearances are those which are produced by some motions (actions) of the patient—e. g., change in form of respiration. . . . Experience has shown that the application (mechanical or electric) is best at the ratio of 1:2 to the vibration number of the intended tone."

Professor Flatau gives a very detailed description of the machine he has invented, with illustrations, claiming that by it he has solved the problem of treatment, which in the first place has to find external, mechanical means for every *heard* tone, which would yield, easily and quickly, the compensating action; and the mechanism of which would correspond exactly, in the number of strokes, with the number of vibrations of the tone, or would at least stand to it in octave-proportion. . . . Flatau claims to produce astonishing results with this treatment—especially in serious cases of phonasthenia (voice-fatigue). One of the features of the treatment is the promptness of results. Flatau has also invented a new "laryngo-stroboscope," which he finds very effective and much in demand. By it mirror-laryngoscopy and endoscopy supplement and correct each other. It easily reveals the larynx in phonation.

"Loss of Correct Tone-Conception, in the Vocally Diseased." By A. Schmitz (Teacher of Singing), Berlin ("Die Stimme," 7).

This author gives his observations from the standpoint of a voice-builder. He has found that the most important symptom of the weakening voice is the gradual extinction and final disappearance of *feeling* for normal tone-attack, and adjustment of the vocal organs for tone-production. Only in especially favorable hours will the sufferer be able, led by hazy remembrance, to innervate a correct tone-placing; but this soon disappears again. In most cases correct tone-placing is almost lost, especially in cases of wrong breathing. These are the cases referred to by laymen as "loss of voice." . . . This, to his mind, is the point where the art of the teacher is at an end, and where the vocal physician must be consulted. (Vocal Art-Science, by forming correct habits of all the autonomies of voice-production, prevents much that otherwise interferes with functional integrity and maintenance of enduring, artistic vocalization. There should be, in the singer who properly controls all the autonomies, only that sense of "comfortable fatigue" which physiologically follows normal physical effort, directed and controlled by the correctly trained mentality of the individual, to perform certain activities.)

"The Soul in Tone of the Human Voice." By Wm. Howard.

To the question, among scientists and amateurs, whether the tone of the human voice is preferable to the tone of mechanical instruments (especially stringed instruments), the frank reply is "No." If there was no text to be sung, there would be no "song-reproductions." That which is *called the principal advantage of the human voice,* is not present in the singing of our artists. . . . The fact that the organ of voice *is a part of the human organism,* makes a *direct transfer* of the *soul-vibrations* of the artist to the tone possible. . . . If the soul is not expressed any more in singing, the voice loses this advantage. This author says, "The vibrato (a subtle trembling motion) has been killed by too much so-called artistic treatment of the voice. We must go back again to nature and start anew."

More schooling for *feeling* is necessary.

"Vibration of the Cranium, during Singing." By Dr. C. Zimmermann, München. A contribution to the doctrine of the objective resonance-symptoms.

There exists no *objective* method or means to determine the resonance symptoms, with regard to voice-formation. All existing devices are faulty, and we have to adhere to the *subjective* method of palpation and by the

phonendoscope: the hair serving as a medium of transmission.—Hopmann (Pedag. Monatschr. f. d. ges. Sprachheilkunde, 1909) has made detailed research with a craniometer by Kocher. . . . For the present researches, which refer to the sounding of consonants and vowels under different conditions, especially with regard to the pitch, a very thin satin cap was used, covering the entire cranium. This cap was divided up into fields where the two vertical seams serve as starting-points. The resulting segments were subdivided by vertical lines, meeting at the seams of the cap, etc. It was ascertained that the cap does not decrease the vibrations. But it is clear that this method is also uncertain, requiring many control sessions; the principal difficulty being to place and hold the tone in the same strength. But practice overcomes this. All trials were made with middle strength of voice, with proper adjustment for tone-production, prior to utterance of voice, and correct utilization of all resonance chambers. . . . With vowels, Hopmann's results were confirmed. Without doubt, A(Ah) yields the weakest vibrations, and therefore the most restricted region. EE (German IE) are strongest (colored against O); and in the middle ground lies U (OO) which leans toward the EE. . . . A well-trained soprano gave vibrations of A, only in an indicative way. With the other vowels, also, at exactly the same vocal strength, a considerable diminution was noted, as compared with the male voice. . . . In all cases, a more or less broad zone was found in the occipital region, nearly or entirely free from vibration; passing over into the region of vibrations, coming from the neck. If A and O were intoned nasally (that is, with a loosened velum palati) an enlarging of the region of vibration took place, which, however (if the vowels under comparison were previously intoned properly—that is, not light and flat), was not considerable. . . . *All consonants* yield a strong vibration; the strongest and clearest being M; N being a little weaker; then follows the labio-dental W, and last, the lingual, L. The palatal, R, showed further diminution with decreasing vibration-region; which, however, does not move backwards. The consonants were, at middle strength of *voice*, intoned at the same pitch as the vowels. . . . When tabulating results, it should not be forgotten that many excellently schooled singers are unable to produce correctly sounded consonants, and others, with great difficulties and after long practice, with correct direction of air-column. This refers not only to the consonants M and N (much used for exercises in adjusting the vocal organs for tone-production), but in a higher degree for the other consonants—especially W and R. . . . With the *crescendo*, a gradual increase of vibration was noted, with a corresponding expanse of the vibration-region. But the extension of the palpable vibration-region reaches a maximal limit, *defined for every vowel and every individual.* Beyond this limit, the vibration-region does not extend, even at the strongest *crescendo* of the voice. . . . Insofar as the increase of vibration does not quite conform to the increase in intensity of tone (as with respective vowels), a slight *piano* will produce an appreciable, comparatively strong, vibration. . . . One is somewhat surprised that the vibration of the roof of the cranium (especially with the vowels Ay and EE) decreases when the tone is pressed (*sforzando*) only slightly, which is proof that *tonality alone* is not the determining factor as to the *degree of vibration*. . . . In this respect the results of the *vocal registers* are of interest. —*Basso:* Within the chest-register no special differences could be found. . . . That is, the vibration-zone is the same for all tones within the chest-register, irrespective of the vowels intoned. But from the chest to the middle register, a gradually weakening of the vibration was clearly perceivable. Within *down* of the vibration-region, with corresponding decrease in intensity, which the middle register proper, this appears in the form of *concentric narrowing* becomes more and more clear with the increase in pitch. This is the more remarkable if we contrast the fact that, according to general opinion, the hitting point of the sound-waves at the palate moves, with increase of pitch, more and more backwards. But, if the objective resonance-perceptions (as far as they are represented in the cranial vibrations) are considered as an

expression of tone-placing, a general movement backwards of the entire vibration-region should be expected. The opposite is shown to be actually the case. Concerning the falsetto, in the lower portion of it (especially with EE and OO[U]) clear, if weak, vibrations could still be detected. With Ah, in many cases, nothing could be felt. With the *head-tones* (with all vowels) all vibrations disappear completely. The same was recorded of the so-called "straw-basso" register; the vibrations disappear with the deepest tones. *It is wrong, therefore, to say that the name "head-voice" has its origin properly in the fact that the resonance-symptoms appear most clearly in the head. It is much more the tone-region called the chest-register, in which, objectively, head-resonance appears most clearly.*

"The Functions of the Vocal Apparatus, Influenced by Training." By A. Ritter (Stimme, Vol. V). *Note.* This article seems to have been written more for the advanced than the amateur singer.—He says: "The ear is the receptacle for tones *sung to the pupil.* The correctly-sung tone is, so to say, the impetus for a successful innervation for the rendering of the desired tone." Further, "The greatest successes in the field of vocal training have so far been achieved by the method of imitation, and far less by methods based on gradual progress after methodical principles." . . . (Vocal Art-Science supplies standard principles whereby the pupil may receive, by physical and psychical training, the fullest development of his individuality as an artist, regardless of the accidental excellence of his teacher as a singer, whose vocal execution alone may serve as the living model for imitation.)

"Cardinal Mistakes in Training the Voice." By Fr. Wohlbeer.—This author is a singing-teacher, and, after rehashing all sorts of psychological and other doctrines, finds that the cardinal mistake usually made by teachers is that children are taught only tone "intuition" (Ton-Anschauung), and not tone-conception (Ton-Vorstellung), by association of tone and tone-names; so that the object, as soon as it enters the region of the organs of sense, reproduces immediately the "name"—and vice versa. He thinks that singing in the public schools is better taught in England than in Germany, and mentions Dr. J. Hullah.

"Visible Tone Vibrations" (Die Stimme, Vol. 3). By F. Wethlo, Berlin.—He has invented an apparatus for ascertaining what overtones a sung tone has. The apparatus is quite complicated, and it is affirmed that twenty or more overtones can be estimated with it. The apparatus of Martens and Struyken are probably more accurate in the work for which they are designed.

"The Obliquely Pulled Uvula." By Jos. Gerhartz (Die Stimme, Vol. 6).—This author offers the results of his own practical observations. He has often found singers who, when at rest, show the uvula bent sideways. His conclusion is that this state is the result of over-exertion in singing. He also observed that singers so afflicted were unable to drop the jaw easily; they opened the mouth diagonally, and in such a manner as to indicate some coördinate cause for both defects. They feel as though they sang on *one* side. Training to overcome the rigor of the jaw (according to the Flatau-Imhofen method) also effected a change in the position of the uvula. Singers who sing with "forced tone" have mostly a diagonally distorted mouth. . . . Naturally, such a deformity injures the clang, and may even *ruin* the voice.

"Voluntary Production of a Double-Tone, in Musical Intervals, in a Singer." Professor Th. Flatau (Stimme, Vol. V) records a singer able to perform this unique physiological feat. Laryngoscopic examination shows no alterations; the ordinary voice has no peculiarities; but the double-voices have a peculiar timbre, resembling reed-instruments, when these two tones are produced. Observation showed at the production, an adjustment of the larynx, depending on a peculiar configuration of the nasal and oral cavities. With an almost closed mouth the posterior portion of the lingual musculature is lifted, vaulted forward, while at the same time the velum palati and palatal

arches approach closely. Further observation showed that the faculty of production of these tones disappeared with laryngoscopic and endoscopic examination, and, in fact, always when the connection between velum and tongue was interrupted. Stroboscopic examination was impossible. Roentgen (x-ray) pictures revealed nothing new. Theoretically it must be remembered that tones can be produced at specially separated points. The possibility of the widest separation between the larynx and the upper cavities (nasal and oral) takes place when, in addition to the laryngeal tone, a labial tone is emitted (whistling). The possibility of a simultaneous whistling and singing, in a perfectly polyphonic form (separate melodies) from a contrapuntal viewpoint, may surprise, but it is a fact. It remains for us to discover whether a laryngeal tone, in the narrow pass between tongue and velum, is possible. Further examination and observation eliminated the possibility, also, that the epiglottis and the posterior wall could form a narrow sounding passage; also the possibility of a "phoning" action of the false glottis. The explanation of the tones can come only from the tones themselves. They are not in thirds, fourths or fifths; but in most of the melodies rendered, the deeper tones referred to are those below the octave and the upper fifth. The double-tone has regularly the volume of a twelfth; but there are other peculiarities. The upper tones correspond in respiration, clang, adjustment in the cavities (nasal and oral), with so-called ventriloquist tones (described by the author in 1896). They are absolutely different, in clang, from the isolated voice of the patient. We shall have to accept, therefore, that although both successions of tones are produced at the vocal lips, the principal places of vibration are *separated in space.*

"The Registers of the Human Voice and Some Results of Experimental Investigation, Regarding the So-Called 'Covered' Singing of the Vowels." By W. Pielke, Berlin (Stimme, Vol. V.) . . . "In antiquity the human vocal organ was considered to be a flute-like instrument, the deep and high tones of which were formed by lengthening and shortening the organ (including the trachea); or by expansion and contraction of the laryngeal area. This doctrine was in vogue from the time of Aristotle up to about 1740, when Ferrein demonstrated the fallacy of this acceptation of the facts in the case, by dissection of the larynx of a dog. He was the first to note the vocal cords and their importance in phonation. Then came Eduard Weber, in 1829, and Garcia in 1854, with their epoch-making discoveries.

Upon the way in which the two vocal lips (cords), more or less stretched by crico-thyroid muscles, resist and act upon the air-column, pressing against them, depends what we call the *register of the voice.* By objective methods, so far studied physiologically (only the chest-voice and falsetto being considered), it has been shown, that with the chest-voice the activity of the contractor muscles predominates; and especially the so-called vocal muscle with the falsetto in tenors. . . . The latest results are: For the chest-voice, rounded vocal lip-edge; pressing the entire voice-body towards the median line, through strong contraction of the thyro-arytenoid muscle, in its entire course; a receding of the action of the tensor; therefore, on clear approach of the thyroid- to the cricoid-cartilage at higher pitch. No conspicuous elongation, but a widening of the vocal cords. Complete closure of the glottis, alternating with an opening of from one to one and a half millimetres; so that, at closure, the vocal cords flatten against each other, thus effecting a complete separation of the respiratory column, passing the glottis; high pressure below the glottis, vibrating the entire surface and body of the vocal cords (length and width); vibration more a *striking* of the two vocal lips against each other.

Falsetto:—No complete closure of the glottis, but only a contraction and dilation, and therefore no complete separation of the passing air-column. Small pressure below the glottis; the vibrations occur at the edge only, the outer parts of the cords remaining at rest, as well as the surface. Edges of the cords pointed; especial contraction of the vocal tensors, with small con-

traction of the vocal muscle. In consequence of the strong action of the tensor, clear approach of the cricoid and thyroid cartilages, with higher pitch: elongation of the entire larynx-picture, from front backwards. The greatest range of the chest-voice is C—c^2. D is artistically acknowledged as the deepest tone in opera. . . . While the esthetic difference between the chest-tone and falsetto tone is great, the physical process is analogous in both. The adjustment of the vocal cords is, in principle, the same; it differs only in grade. In woman, the internal vocal muscle is more active than in man. . . . The so-called head-voice is, by physiologists, included in the falsetto; but not in practice. . . . Of especial importance for artistic singing is a point, known to singers, but still unexplained by physiological research. It is the so-called *voice-break* in the middle and upper parts of the chest-voice, and its compensation by so-called "covering" (Deckung).

New Discoveries Regarding the Human Voice

By Dr. O. RUTZ, Munich, 1907

Not the muscles of the face (the movements of which have to do with mimics and physiognomics) are under consideration in Dr. Rutz's work; but the movements of muscles so far entirely neglected in this connection. They are the muscles of the trunk, which he considers as producers of emotional qualities; emotional degrees of warmth and strength; relation between temperament and action, etc. It is not a question of quick, changing motions of muscles—expressions of sorrow, exaltation, etc., produced by the facial muscles; but of the adjustment of body-muscles which "may last sometimes for life." Where there is motion, says Rutz, there is form (shape); the motion of the body-muscles giving the human body an important and significant form. To persons of different *emotional* qualities, this muscle-motion will give different corporal shapes. Also, to continue in this line, differing forms of body cause the voice to sound differently, showing degrees in warmth, strength—revealing different clang-qualities and clang-peculiarities, the explanation of which, so far, has never been satisfactory, and which have been crowded into one category under the conception of "clang-color" (Klangfarbė).

He holds that each and every emotional quality has its special expression in the body-muscles; its special "expression-tonality" or phonetic clang, and that no other expression-motion (of the muscles) or tonality exists for it. Music, expressing emotion, must be sung in accordance with the same natural laws of tonality, and with the same *adjustment* of the body-muscles, which express the peculiarity of the emotions manifested in music. If this is neglected—this *natural law*—the *artistic effect* diminishes; all sorts of faults appear, and the voice suffers in various degrees from slight deterioration to its total loss. . . . He finds that, in musical and rhetorical art, the *voluntary* and *conscious* control of this expression-position and tonality must be realized by the artist; its involuntary and unconscious use being found among the foremost singers and orators. But—*one and the same person may*, voluntarily and consciously, in addition to the body-motion and expression-tonality of its *own* temperament, adapt *foreign* temperamental and emotional qualities, and thus be enabled to fulfil the principal conditions for the *best* reproduction (recital) of musical and rhetorical works. . . . He further affirms that the old doctrine that the parts of the human tone-organ above the larynx produce clang-color is untenable. "The parts *below*, the muscles of the trunk, give softness, color, etc., to the voice. As the vowels are produced by different adjustments of the resonance-chambers of the upper vocal regions (Ansatzrohr), so the general clang-qualities of the voice result from different muscular adjustments of the body, below. As in the matter of the general *clang-qualities* of the voice, the doctrine of the general emotional qualities (warmth, power, etc.) and of the *temperament*, require revision." . . . The new doctrine can also be used as an instrument for ctiticism. I makes it possible, according to a given case, to ascertain the author (from its rendition)

of a musical or rhetorical work. The expression of the general emotion-qualities of the temperament may be "read" from the peculiar diction of the tone-lines—the melody—the "emotion-style." Thus, he claims, it is possible to discover the name of an unknown author from the way his music is interpreted, in accordance with the law of "expression-tonality and expression-position" peculiar to the composer. . . . The new doctrine begins with the individual person, and extends to nationalities (folk-songs) requiring the same expression-tonality, body-position, etc. Furthermore, he says: "The absolute necessity for reform in the production (rendering) of tone- and word-poetry through the voice, is evidenced by the new doctrine. It shows that even the most eminent singers are below the standard, and are wrong. This reform can be accomplished only along the lines of the new doctrine. This reform must, moreover, extend to the improvement and elevation of taste of the public." . . . The relations of the *muscle-motions* of the face and *emotion*, have always been a matter of research—(how to *express emotions without feeling them*). The essence of this relation is that *every emotion* has a decidedly *certain expression-motion*, which any person may adopt knowingly. . . . This peculiarity should always be borne in mind, as it is necessary for the comprehension of the *whole doctrine*. If an emotion is designated as "sorrow," it does not give expression to its whole character. "Sorrow" is a name, expressing only *one* of the qualities—but says nothing of its *warmth*, *strength*, *depth*, *movability*, etc. Therefore, we shall call the first the *name-giving*, and the second the *general* quality. Both qualities possess muscle-motions: the first ones, *face-muscle-motions;* the second, *body-muscle-motions*. . . . Every poem (sung or spoken) expresses the emotional life of the poet. The peculiarity of his emotion finds expression in a peculiar succession of words or tones. It is, in the *emotional* style of his works, in opposition to their *artistic* style. This *style* of the works, conditioned by the warmth, strength, etc., of the expressed emotions, demands from the voice different requirements, technically, for the accomplishment of which always, only *one mode of use of the vocal organ is fit*. It is the whole tone-organ influencing body-muscle-adjustment, which belongs to the general emotion-qualities expressed in his work.

NOTE.—Throughout this work, "New Discoveries Regarding the Human Voice," by Dr. O. Rutz, 1907, detailed and specific exercises are given in order to carry out, in a practical manner, the new doctrine—a brief exposition of which has here been submitted.

New Means of Demonstrating the Characteristics of the Vocal Quality of the Overtones

By H. J. MOSER, Berlin

(Arch. f. Experimentelle u. Klinische Phonetik. 1914-15.)

The author has succeeded in discovering an acoustic phenomenon whereby it is possible to demonstrate in an effective manner, to the pupil, the vowel-forming quality of the overtones; and also a way of utilizing it in the psychological and physical aspect of tone-production, while under training. The method requires no apparatus. The author started with the fact that the neutral vowel (or, better, the vocal lip-tone, not yet characterized as a vowel—the wave-shape of which approaches pretty close to a full sine-curve) receives, at its entrance into the oral and nasal cavity-system, through the admixture of overtones, that *clang-character* of the human voice frequently designated "primary" vowel. This is finally to be moulded into an especial vocal clang by the fact that the oral cavity assumes, through certain adjustments (especially of tongue and lips), the size which corresponds respectively to each individual tone with its own resonance. Just as each individual

tone corresponds with the absolute pitch of one of the overtones contained in the sung tone, it increases, as resonator, this overtone to such an extent that it becomes a vocally characteristic clang common to both (Beiklang).

If such a vowel is formed at medium tone-height and tone-strength, under that adjustment of the oral and nasal cavities (Ansatzrohr) which is best for utilization of the resonance of the oral cavities, and which is the final goal in tone-formation of all artistic singers, every person more or less able to analyze clang-complexes by mere estimate, will be able clearly to distinguish the overtone determining the peculiarity of the respective vowel-clang from the total clang, if not for all vowels, certainly for some—especially the closed vowels. . . . With some practice, it is possible to produce these phenomena voluntarily.

Tartini, as early as 1754, recommended the employment of the lower combination tones (Differenztöne) discovered by him, as a means of control for the clear intonation of double-stops, in violin-playing. Moser raises the question whether such an overtone, through the proper formation of the self-tuning oral cavity, could be increased to such an extent that the average or untrained ear could distinguish it from the *complex* of the clang as a separately audible part. It was found that the ear could easily be directed toward the overtone to be discovered, if several next-neighbor, harmonious partial tones could be produced in immediate succession. The conditions for making audible the vocally characteristic overtone are especially favorable with the vowel-succession of open oo (as in cool); closed oo (as in cook); open ee, and closed ee (probably because of the smallness of the anterior oral cavity, acting as resonator). . . . In accordance with the foregoing production of our vowel-series (equal strength and height of the vocal lip-tone always provided), it is nothing else than an increase (assuming constant relations of the other clang-factors) of all the partial tones of the *sung tone* (or at least those of a certain connecting section of its overtone series), successively from deeper to higher vocally characteristic effect by the fact that the specially decreasing cavity of the mouth, for each of them, for the time being, forms the resonator: in fact, is the proper resonance-tone (Eigenton) through the greater dilation of the oral cavity.

The fact that the resounding oral cavity does not produce the overtone, and afterwards admixes with the vocal lip-tone, but only increases resonatorically an already existing partial tone, is shown by the fact that at the above-described *continuous* transformation of vowel-adjustment, the proper resonance-tone, corresponding to each respective form of the oral cavity, ascends *continuously*, while the changing partial tone should ascend in interval leaps (peculiar to the overtone-series), that is, in the form of a stopped (abgebrochen) chord.

A new phenomenon. That the series of overtones contained in the sung tone, sound in the shape of a chord-succession (immediate) as clearly as if one would analyse, with the prism, the sun-ray into its spectrum, appears as soon as the sung tone of the OO-clang is gradually transferred in the well-known way to the EE-clang. If, for example, a baritone sings the tone g, then, with the OO-adjustment (a full oral resonance provided), the third overtone (quint d^2) will be clearly audible. If the oral cavity is gradually diminished in the way stated above, the overtone will not rise continuously with the same acceleration, but will jump suddenly to the fourth overtone, g^2, while at the same time the open OO has narrowed down to the closed OO. Now, while this vowel is gradually changing its form toward EE (German ie), the overtone jumps suddenly from g^2 to b^2; which means that the oral cavity has meanwhile become so small, that its proper resonance-tone cannot react any more on the fourth, but only on the fifth overtone of the fundamental sung tone, g, and increases the latter to a vowel-characterizing overtone. With the jump to the sixth overtone, d^3, the closed OO is reached, and at the natural seventh, f^3 (discernible with especial clearness because of its small *blending* quality), the closed OO becomes audible.

NOTE. The above is indicative of the manner in which Moser works out his proposition, and, in the before-mentioned article, from which the foregoing is extracted, much more along the same lines is elaborated with much detail and exhaustive care.

Harmony and Complication

By Dr. VICTOR GOLDSCHMIDT, Heidelberg. 1901.

Harmony is concordance between the outer world and our feeling (Gemüt), connected by *concordance with the senses and the mind.* Such concordance brings us joy; we desire it, and *this desire is the motive power* for our creative activity in harmonious production. . . . Harmony is the key which unlocks Nature to our understanding. Each one of the senses comprehends more or less harmony; the most perfect being the sense of hearing in the enjoyment and creation of music—that is, the harmonious grouping of agreeable tones. Then, the sense of sight, in choosing and arranging harmonious colors, and masses in space, into formative art-products. But the mind (Geist) and feeling (Gemüt) show Harmony—creating and enjoying..... Now, Harmony, in all its varied forms, is governed by a simple law of appearance and development, the Law of Complication; by which is meant the law of developing the *complex* (complicated) from what *appears*, at first, to be *simple*: or, variants from the basic fundamental. This law we find objectively in the differentiation of the products of Nature, from the simple to the finely divided (articulated); similarly in *tones* and *colors*—and especially in the precise formation of *crystals*. . . . Know thyself! is the goal of all science. All things exist for us only in so far as our senses can receive, and our reasoning faculty can absorb (assimilate). Our ability to understand the outer world may be explained in this way: In our mind (microcosmos) processes take place which are analogous to processes in Nature (macrocomos). Those phenomena of the mind which, in their operation, are analogous to those in Nature, we call "*Laws of Nature.*" The laws of Nature exist for us only in so far as they, at the same time, are recognized by us as laws of the senses and of the mind. When a law of Nature is seen to be universal in its application, it becomes a recognized *fundamental* law of science. Such a law (Goldschmidt believes and promulgates) is the Law of Complication, whereby manifold crystalline forms develop from simple structures. The entire development of crystalline forms, emanating from certain primary surfaces, is governed by the Law of Complication. This law, at the same time, includes *the law of rationality of the indices; the law of zones; and the law of constancy of angles*. . . . So far, it has been held that the law of rationality of the indices is something special, referring only to crystals. But this is not the case. It is clear that the law of complication (of which the law of the rationality of the indices is only a part) points to other, larger grounds, and that it is the law of *Harmony* which imprints its mark on *music.* If this conclusion be correct, it explains certain structures of the *ear*. It is present *objectively* in the *spectrum-lines;* subjectively, in *colors;* and enables us to understand the *eye*. . . . The crystallographic *law of complication* appears as a far-reaching law of development of manifold nature-forms, and even of the human senses and mind. Without a knowledge of the Harmony of Tones, the Harmony of Crystalline Forms remains unintelligible; and, on the other hand, Harmony in Tone and Color can be perfectly explained only with the help of Crystallography.

(For a full treatment of this subject by Goldschmidt, see his articles in the Zeitschr. f. Kryst., 1896, 26: 7; 1897, 28: 25. Only a brief outline of the principles may be given here.)

"Crystals are covered by even planes of different forms and systems and various numbers. Some of these planes are of more, and some of less, importance on account of their size as well as their number. *With increasing size*, number, as well as accuracy of observation, *diminish.* The planes of a

certain *kind* have their *gradations:* principal planes, primary planes (also called primary knots); this latter having reference to reproduction by projection, in which these planes have the shape of points or knots.

Now, it appears that the weaker, *derivative,* planes insert between the principal, *primary* planes in a *certain* manner.

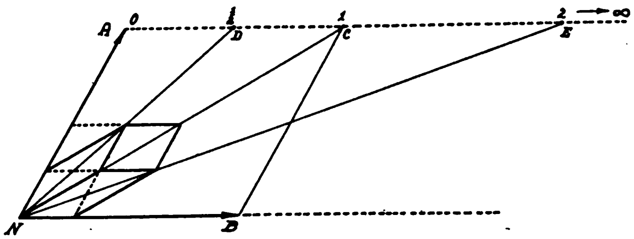


Fig. I.

In the above Figure, Harmonious numbers, 0, ½, 1, 2, to infinity (00), are equivalent to diagram line, A—E.....

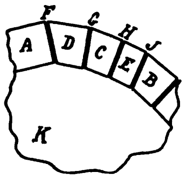


Fig. II.

If AB, Fig. 2, represent *primary* planes, then, according to the Law of Complication, producing differentiation, plane C will be formed, which truncates the parallel-edged planes, AB. Under a certain angle, C is weaker, lower in grade, than AB. Still further progression of the law of complication, and we have the planes DE which truncate the parallel-edges, AC, BC. The planes D and C are weaker than C. Further progression produces the weak obtuse edges F. G. H. J. We have here *three* stages of regular, progressive development. . . . Explanation:—NO (Fig. 1) equals AB (Fig. 2); NI (Fig. 1) equals A C B (Fig. 2): N½ (Fig. 1) equals A D C E B (Fig. 2); N 2 (Fig. 1) equals A F D G C H E J B. . . . The *derivative* planes form with them a *primary* zone, characterized by *parallel* edges. The *first derivative* plane, C, is called the *Dominant*; when located between two-primary planes, *Primary-Dominant.* The same development may take place at the edge between two other primary planes, for example, between A K, or B K (Fig. 2). We say primary zones—AB, AK, BK—span between primary planes (primary knots), ABK. Further progressive differentiation yields zones between each primary plane, and a *primary-dominant.* For example, CK, secondary zones —then between every two Primary-Dominant (tertiary zones). The two planes between which a zone stretches, is called the end-knot of the zone. The zones, also, having their gradations, with this development a great wealth of form is created—especially if the number of Primary-planes is large, and if the differentiation in zones reaches far: say, to N 2 or beyond. In every zone, the arrangement of planes follows a certain numerical law, which is the same for all zones, and all crystals. *This is called the Law of Complication.* It regulates the place and inclination of the planes, their size and gradation, and permits the prediction of unobserved planes as

probable; also examination as to their probability of observed ones. (See Zeitschr. f. Kryst., 1897-1900.)

In Music, *Harmony* is the selection of harmonious groups of tones. It is the work of Man, is a reflection of the human mind, is something common to humanity. Unlike the formation of crystalline forms in one respect, Musical Harmony is the result of voluntary selection of its elements; while the formation of crystalline forms is the result of natural forces, unaided or acted upon in any way by man. Yet the fact remains clear, that the same general Law of Complication operates in both realms; and tone-groups are subject to the same Law of Complication. From this law emanate the elements of musical harmony; the composition of musical chords, scales, key, etc. (As early as 1818, Chr. S. Weiss demonstrated the relation between crystalline forms and harmonious tones. He compared, in the regular cube, octahedron, tetrahedron, dodecahedron, etc., the length from centre-point to corners, with the edge- and plane-centres, and draws an analogy between their ratio, 3:2:4:3, and the vibration-ratio, 3:2:4:3, of the tones.) Scale is the series of tones within an octave, with ascending vibration-number. Of all possible tones used in music, within an octave, only a limited number are selected for scales. Depending on this selection, we distinguish three kinds of scales: Diatonic, Chromatic, and Enharmonic. Let the letter Z represent the fundamental tone (the Key-tone), for example, C (this may as well be A, or G, or D), then the general form of a scale is, in numbers: Z= . . . 4/3. 3/2. 5/3 . . . 2. etc.

"This interesting, if somewhat abstruse, subject is continued, by Goldschmidt, to show the similarity between the crystallographic numeral laws, and the analogous laws by which the several scales and chords are derived—in accordance with the progressive differentiation of the Law of Complication. In a treatise of the present scope, little more than a brief, though, we hope, comprehensive statement of the law, with a few illustrations, can be offered."

Acoustics and Mechanics of the Human Voice

By Dr. ALBERT MUSEHOLD

TONE is not *primary*, but is made up of many separate "tones": its predominating *fundamental* (which determines the height of the tone, proper), and a varying number of so-called "overtones." These "harmonics" (as they are usually called), or overtones, stand in a positive ratio to the fundamental, so that the number of their vibrations is 2:3:4: etc.

There are, for example, the overtones of C:

(a)	The Octave	——c ——	2	(1/2 length of string)
(b)	The Fifth	——g ——	3	(1/3 " " ")
(c)	2d Octave	——c^1 ——	4	(1/4 " " ")
(d)	The Third	——e^1 ——	5	(1/5 " " ")
(e)	The Fifth (octave)	——g^1 ——	6	(1/6 " " ")
(f)	3d Octave	——c^2 ——	8	(1/8 " " ")
(g)	The Second	——d^2 ——	9	(1/9 " " ")
(h)	The Third (octave)	——e^2 ——	10	(1/10 " " ")
(i)	The Fifth (2d octave)	——g^2 ——	12	(1/12 " " ")

Dr. Musehold speaks of the usual sine-curve:

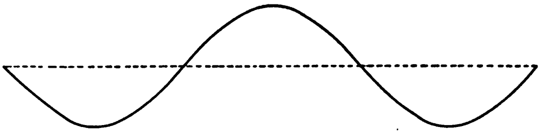


Fig. III.

and says that the curves of musical tones are essentially different from the sine-curve shown. He draws his curve from several points, as shown at (A) below:

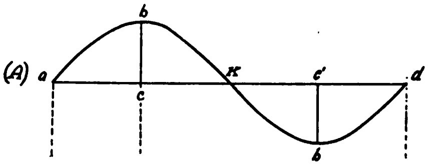


Fig. IV.

From c to c^1 constitutes a half-wave length. At (B) he shows graphically, from the "side view," so to speak, how condensation and rarefaction occur in the production of tone:

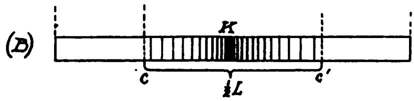


Fig. V.

The shaded section, at "K," shows condensation; the light portion, rarefaction. Note the corresponding letters in both (A) and (B) for a clear exposition of the question as Dr. Musehold describes it. "K" represents the node, or place where the vibrating string is stopped. In the following diagram are shown several divisions—1, 2, 3, 4, 5—representing the octave, fifth, second octave, third, etc., as listed on the foregoing page.

"The author proceeds to show, by description and illustrations, the similarity between the wind-instrument (musical) and the human voice machine: the alterations in the mouth-cavity for the production of various vowel-sounds, etc. He speaks of the importance of the tongue in its muscular attachments by muscles from above and below, and describes various movements of the larynx as influenced by the tongue, etc. He describes the arytenoid, to which the forward end of the vocal cord is attached; acknowledges that the arytenoid moves about its base, but does not give the action of the arytenoid for any pronunciations, as is done in Vocal Art-Science."

It has been mentioned that the bottom thyroid horns are attached to the cricoid. It can be seen, then, that both thyroid and cricoid may move about an axis (see Fig. 32-a) which is common to both bodies. These movements are accomplished by the crico-thyroid muscles. . . . In a contraction of these muscles, the thyroid and cricoid are brought closer together. In general it is assumed that the cricoid remains stationary while the thyroid moves down, in the arc of a circle. Referring to Fig. 31 (Dr. Musehold's book), the muscular action of the crico-thyroid muscles is represented by the arrows "pr" and "po." The resultant line of action is "ix" (principal force) and the thyroid will be drawn downward and forward about the axis (a). In this change of position, there occurs a lengthening (e, f) in the vocal cords. The rear point (e) in vocalization, shows the arytenoid as remaining fixed to the cricoid and stationary, while the front part (f), included in the angle formed by both sides of the thyroid, must have, practically, the same movement as the thyroid about the axis (a). Joining the point (a) with (f) by a straight line—with (a) as a centre, and (a, f) as a radius—the arc of a circle will be described which will represent the movement of the point (f) as it moves with the thyroid about the axis (a). Now, if (f) is drawn downward and forward, the point (f) will follow the arc of the circle to the vicinity of

the point (g). Now, the point (f) has not moved farther away from (f) because "f-a" and "g-a" are radii of the same circle and therefore must be equal; but "e-g" is longer than "e-f", since it is opposite the greater angle in the triangle "e-f-g." Now, if "e-f" be projected on "e-g" to "h," there will

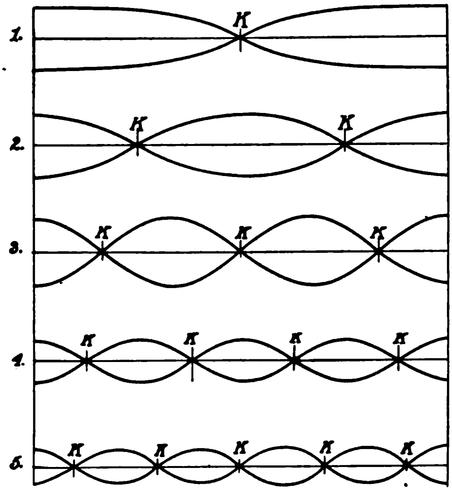


Fig. VI.

be a short segment, "h-g," overlapping, which will correspond to the elongation or tension of the cord. This mechanical action of the thyroid resembles a lever (a-f) fastened at (a) with one end at (f) on the horizontal vocal cords to actuate them.

Examination of the glottis and surrounding parts by means of the Stroboscope.

This optical instrument, discovered in 1832 by Prof. Stampfer, of Vienna, consists of a metallic disc with a number of slot-holes located regularly around the outer edge. This disc may be revolved at any desired speed by means of a driving-motor or clock-work attached to it. There is a slot in the centre of the disc, and during rotation the eye peeps through this slot, while the reverse side of the disc is illuminated. The principle of the instrument rests upon the fact that the light-impression in our eyes exists for a short interval of time, after the source of light has been removed. Thus, in revolving the disc, the eye receives rapidly intermittent impressions of light, alternated with darkness, as the slots pass and repass during the revolution, Since the alternations from light to dark occupy but one-seventh of a second, a person standing in front of the revolving disc, with light behind, it will see through the rotary, perforated disc what appears to be a steady, unbroken illumination of any object back of the disc. It appears a little darker than if seen with uninterrupted light, but quite clear. The cut opposite gives a simple outline of the stroboscope. (See Fig. VII.)

The stroboscope was designed and is used to observe, during illumination, bodies in motion. Oertel used his stroboscope to study the action of the vocal cords which he had attached on an elastic membrane. Consequently, his suspended cords led him to erroneous conclusions. . . . As to the action

of the glottis, Oertel says only that it is smaller in chest-register than in falsetto. . . . Dr. Musehold now proceeds to take flash-light photographs through the stroboscope—"stroboscopy." He finds that, in the chest-register, the vocal cords are close together—the glottis is always shut in this register. On this account, he took stroboscopic photographs showing the opening and closing of the glottis. He noted that, in singing (a baritone) c, the vocal cords appeared to be pressed together. He noted that, in this case, the position of the cords could be maintained fairly well. . . . He concludes, from these observations, that the period of glottis-closing is longer than the

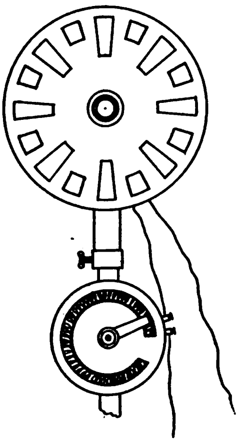


Fig. VII.

period of glottis-opening, and the vibration could be fairly well represented as in the illustration below.

The horizontal lines show the closing of the glottis, while the triangular lines show the opening. From an examination of curve A, it can be seen that there is not a complete agreement of the tone sung, and the disc, inasmuch as the disc always changes *toward* the point (a) as the glottis-closing comes to light. Examining the point (b) however, which shows the maximum

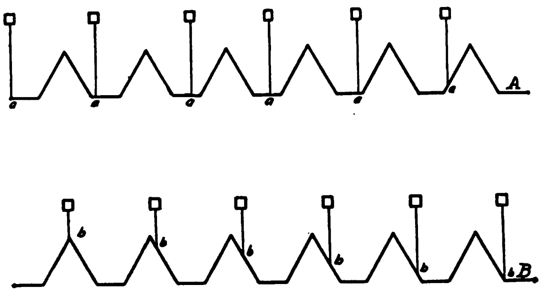


Fig. VIII.

proximity of the vocal cords, a small difference in both tones can be detected. . . . The curve in the above illustration (A) (B) agrees in principle with the curve which P. Gruetzner arrived at from a study of the vibration of

the raised tongue, by graphical and optic research methods. It is a fact that the raised tongue and glottis (in chest-register) have the same duration of vibrations, since they are both influenced by the same interruptions of air-blasts. . . . The vocal cords close, by muscular action, so that they are pressed together, more or less, and remain in this position until they are pulled apart by a new blast of air. The stroboscopic photographs of Dr. Musehold's interesting and valuable little treatise are in two sizes, and can be seen in his work referred to above.

The Scientific Measurement of Musical Talent

By Professor CARL E. SEASHORE

The Tonoscope

An ingenious apparatus invented by Carl E. Seashore of the University of Iowa, on entirely new principles, for the detection and measurement of deviations of the voice-pitch.

In "The Psychological Monographs," Vol. 3, Jan., 1914, published by the Psychological Review Co., Princeton, N. J., the inventor describes the principle, construction and technique in detail. Outlining the description, the Tonoscope works on the principle of Stroboscopic vision, the principle of moving pictures. Auditory vibrations of air, caused by voice or musical instrument, are converted directly and instantaneously into visual configurations on a screen, and the vibration frequency which denotes the pitch of the tone may be seen in plain figures on a scale. This enables us to measure the pitch of any tone by direct inspection while singing, speaking or playing under normal conditions. In moving pictures it is well known that successive pictures which are alike, thrown on the screen in the same place and in rapid succession, will form one continuous picture, which stands out clear and still. This is the principle employed here.

The structure of the apparatus shows a revolving screen rotating at the rate of one revolution per second, which carries rows of dots, regularly spaced but varying in number for each row. When a tone is sounded, the row which has the dot-frequency that corresponds to the vibration-frequency of the tone will stand still and be clear, while all other dots move and tend to blur. Each row runs under a number of the scale. The row which stands still, therefore, points to a number which designates the pitch of the tone. The screen contains a sufficient number of rows of dots, varying in number, to correspond directly, or by multiple, to all tones within the range of the voice. To see the pitch of the tone one has therefore only to see the number of the line that stands still. A synchronous motor drives the drum (screen) at a regulated speed, thus assuring accuracy in the control of the movement of the exposed object.

A large 10 v. d. tuning-fork is used as an interrupter. It is energized by primary cells, and is encased in a box which is kept out of the way in a closet so that no noise shall come from it.

A 16 c. p. lamp is used for resistance in the motor circuit, and is mounted between the prongs of the fork to assure a sufficiently constant temperature.

A 110-volt direct current is completed through the motor and a mercury contact interrupted by the fork. The current is reduced by the lamp resistance. The make and break is short circuited with a condensor to avoid the forming of an arc.

A rheostat inside a tonoscope case, with a switch on the surface, serves for the adjustment of current, as there may be fluctuations in the supply main. A small detachable brake for starting fits the end of a main shaft which comes out flush with the edge of the case on the side.

To start the tonoscope one has only to start the fork, give the drum a turn up to approximately one revolution per second and close the switch. Once started, the instrument will run indefinitely without special care.

In the Musical Quarterly for January, 1915, the inventor explains, under the caption "The Measurement of Musical Talent," the problem to be solved, and shows that "the psychology of music is now being built up in the laboratory from three points of view, namely: The psychology of individual talent, the psychology of æsthetic feeling in musical appreciation and expression, and the psychology of the pedagogy of music." The discussion is limited to the first of the three aspects.

Musical talent being inherited, not acquired, is inborn, and can either be developed or remain latent; that is, as the saying goes, talents may "die with all their music in them." Both, the talent as well as the developed talent, can be measured. "The measurement of musical capacity, therefore, concerns itself chiefly with inborn psycho-physical and mental capacities as distinguished from skill acquired in training."

Only as far back as 1842 it was considered impossible to measure the speed of nerve-impulse or the "time of thought;" and yet not only has all this been overcome, but to-day the science of individual psychology virtually "dissects" the genius, analyzes and measures talents, sets out limitations, diagnoses the possibilities, and directs the development of the individual.

Musical talent is complicated; it consists of groups, or hierarchies, of different characteristics in different individuals. The analysis of musical talent tries in the first place to locate the dominant traits and then determines qualitatively and quantitatively the composition or characteristics of each group, or hierarchy of traits. Therefore, the term musical talent is to be used in a collective sense.

Then Seashore goes on to say: "The elements of musical sound are really three, namely, pitch, time and intensity, of which pitch is the quality and essence of a sound. This classification of the fundamental aspects of musical sounds gives us a basis for the classification of musical talents into the ability to appreciate and the ability to express respectively pitch, time and intensity of tone. Each of these may be subdivided in great detail.

As to the human side of music, capacity for the appreciation and expression of music may be divided into four fundamental capacities; namely, *sensority*, the ability to hear music; *motor*, the ability to express music; *associational*, the ability to understand music; and *affective*, the ability to feel music and express feeling in music. By combining these two classifications (the elements of musical sounds and the capacity of the human individual) we obtain the principal groups of musical talent.

Arranging the principal measurements now available in the psychology of music laboratory on the above basis of classification, we get a scheme like the following list of measurements on a singer:

I. Sensory (ability to hear music).

A. Pitch.

1. Discrimination ("musical ear," tonal hearing).
2. Survey of register.
3. Tonal range: (a) upper limit, (b) lower limit.
4. Timbre (tone-color).
5. Consonance and dissonance (harmony).

B. Intensity (loudness).

1. Sensibility (hearing ability).
2. Discrimination (capacity for intellectual use).

C. Time.

1. Sense of time.
2. Sense of rhythm.

II. Motor (ability to sing).

A. Pitch.

1. Striking a tone.
2. Varying a tone.
3. Singing intervals.
4. Sustaining a tone.
5. Registers.
6. Timbre: (a) purity, (b) richness, (c) mellowness, (d) clearness, (e) flexibility.
7. Plasticity; curves of learning.

B. Intensity.

1. Natural strength and volume of voice.
2. Voluntary control.

C. Time.

1. Motor ability.
2. Translation and attack.
3. Singing in time.
4. Singing in rhythm.

III. Associational (ability to imagine, remember and think in music).

A. Imagery.

1. Type.
2. Rôle of auditory and motor images.

B. Memory.

1. Memory span.
2. Retention.
3. Redintegration.

C. Ideation.

1. Association type and musical content.
2. Musical grasp.
3. Creative imagination.
4. Plasticity: curves of learning.

IV. Affective (ability to feel music).

A. Likes and dislikes: character of musical appeal.

1. Pitch, timbre, melody and harmony.
2. Intensity and volume.
3. Time and rhythm.

B. Emotional and reaction to music.

C. Power of æsthetic interpretation in singing.

For the method and technique of these measurements consult Seashore's "Psychology in Daily Life," D. Appleton Co., 1913, Chapter VII; also "Psychol. Rev.," Monog. No. 38. Special consideration was paid to Individual Difference, Norm, Cognitive vs. Physiological Limit, Reliability and Success, Illusion of Pitch, Absolute Pitch, Tone-deafness, Practice, Age, Sex, Elemental Nature of the Test, Basal Nature of the Test, Theory, Intelligence, Inheritance, Tonal Range, Evolution.

Then the mass of material and the numerical records obtained were reduced to a sort of common denominator by a method of percental rank which furnishes a common unit.

This system of measurements is unfortunately not adapted for general use by musicians themselves, as it presupposes a technique, an equipment, and a skill in psychological analysis which the musician does not possess; it requires a specialist trained in music and in psychology, and opens a new profession. Seashore recommends the establishment of laboratories in the principal music-centres, as it is of the utmost interest to prospective singers to secure a chart of their talents before adopting a life-work. But demand for such services will also (and perhaps more) be among musicians who have encountered some serious obstacle, to determine its nature and whether it is reparable or not.

But there is also place for the measurement of musical talent outside the laboratory; it can be adapted to the needs of teaching, as a means of training. In singing, correction of pitch, timbre, time, etc., can be made most effectively if the pupil practices with an instrument which reveals to the eye of the singer the actual pitch of the voice to a hundredth of a tone on the principle of moving pictures, the pupil training his voice by his eye. Such an instrument is the Tonoscope described above.

Finally, Seashore recommends the adoption of the Tonoscope in Elementary Schools, not only as a means to eliminate helplessly unmusical pupils and to save them from an intolerable imposition of musical requirements, but also as an instrument to solve the "mysterious puzzles" surrounding talent and the human mind in general.

GLOSSARY

Abscissa—That part which is cut off. In mathematics, that part of a transverse axis of a conic which lies between the vertex and the perpendicular ordinate to it from a given point on the conic. In Vocal Art-Science it is used to designate an apex such as is formed at the common point of intersection of three planes.

Activation—The act or process of rendering a thing active.

Adenoids—Normal, gland-like bodies in the pharynx; the "pharyngeal" tonsils; which, like the "faucial" tonsils, frequently become inflamed and enlarged.

Ægophony—(Greek, *aix*—genitive *aigos*—a goat; and *phone*, voice). A disagreeable vocal quality resembling the bleating of a goat. This voice is frequently heard on the modern vaudeville stage, and is emphasized when reproduced on the phonograph.

Akinesis—A condition opposed to motion. A static condition. (See KINESIS.)

Amygdelokelphine—To shell out the tonsil without injury to its capsule, so that all functions of voice due to capsule or other parts are preserved. An original Vocal Art-Science term, invented to show how the tonsil should be taken out. A term proposed by the author.

Antrum—A name of various cavities in the body, but when used alone signifying the antrum of Highmore.

Aperture—(Latin, *apertura*, an opening). The mouth is an aperture; also, the nostrils. Sphincteric aperture—an opening which is closed by a circular muscle, surrounding the opening, or aperture, e. g., the "orbicularis oris."

Aperture at the hypothenuse—Assuming the cells of the body to be pyramidal, the base being in the form of a 3, 4 and 5 triangle, the side corresponding to the hypothenuse will be in the aperture.

Apex of a triangle—The intersection of the two sides, neither of them being the base. It is the vertex or point of the triangle opposite the base or side upon which the triangle is supposed to stand.

Aphonia—Privation, or loss of voice, or the sounds giving rise to it.

Appendix—That which is accessory to or dependent upon another.

Arytenoids—Articulating pyramids of the vocal cords. When the tail disappears in the frog a small triangular pyramid of tissue, the arytenoids, appears in the lower end of the glottic sphincter. Composed of cartilage. Shaped like pyramids. Located at the base of the cartilage of Santorini, and work on facets placed in an equally balanced position on each side of the cricoid. Control the action of the true vocal cord. They polarize and equilibrate the first expiratory vocal sound. Without the arytenoids there would be no articulate sound.

Auto-Laryngology—The practice of examining one's own throat and larynx; especially harmful in the case of an inexpert person.

Balance—A state of equilibrium or equipoise.

Bilateral—Two-sided; having two sides; the sides may or may not be symmetrical.

Bipolarity—Where two poles connect an autonomy. In a brain-cell, the two hemispheres are doubly polarized, two positive and two negative.

Breath-Clutch—A Vocal Art-Science expression to indicate the exact control of breath. It is the synchronous, combined and triple action of the diaphragm, lower intercostals and oblique abdominal muscles, compressing the lungs and furnishing the true breath-power of the voice. A term proposed by the author.

Bronchial—Referring to the bronchial tubes; the bronchi (plural of *bronchus*); the lower division of the trachea, or wind-pipe, which becomes the two bronchi, further dividing, tree-like, as they penetrate the lungs and finally reach the air-cells.

Buccal Cavity—(Latin, bucca, cheek, when puffed out by speaking or eating). The cavity of the mouth anterior to the line of the soft palate; is the space where resonance (vocalic pitch) is determined.

Capsules—(Latin, *capsula*, a little sac). A membranous sac or envelope, as the capsule of the crystalline lens of the eye; also, of the tonsil.

Cell (Vital)—The microscopically small vital element, which is the unit of structure in all tissues—nerve, muscle, bone, etc., and contains a nucleus, or vital centre of activity.

Centrifugal—The force tending to pull a rotating body away from its centre.

Centripetal—The force tending to keep a rotating body intact; opposed to *centrifugal*.

Cervical—(Latin, *cervix*—genitive *cervicis*—the neck). Referring to the neck, as cervical vertebræ (the first seven vertebræ, located in the neck); the cervical muscles, also vessels and nerves.

Choanæ—From the Greek, signifying a funnel, and refers to the form of the two openings seen when looking above the soft palate, from behind. These funnels contain the turbinated bones. The place where nasal resonance begins. According to Vocal Art-Science, it gives to the hollow pyramid in the dome a leeway for polarization and defraction without which the resonance of the voice could not exist.

Chorditis Vocalis—Inflammation of the vocal cords.

Cicatrization—The act or process of inducing a cicatrix, or scar, in the healing of a wound.

Contrapuntal—In Vocal Art-Science, a point of opposition or contrast with another point. Two poles, balancing each other, having a different effect, influencing the positive and negative poles of every well-regulated autonomy. Always at right angles to polarization. Lateral poles of power as distinguished from the vertical poles.—For example: The positive pole, the centre of the diaphragm; the negative pole, the centre of the glottis; contrapuntal poles, the third dorsal vertebra to the centre of the manubrium, or breast-bone.

Coördination—The automatic action of the various muscles throughout the body, without the *conscious* direction of the will; hence, a bodily or physical attribute.

Cord-Stretching—The muscles of cord-stretching pull the thyroid cartilage from the back upward and forward, and from the front down and backward; swinging the thyroid cartilage in its socket on the cricoid cartilage below. Thus stretching the vocal bands from the arytenoid to the thyroid, and the latter action gives the proper angle of momentum for its spontaneous delivery. When fixation and cord-stretching are well adjusted, a voice has the principal requisites for fine use.

Cornicula—(From Latin, *cornus*.) Little horns; in anatomy, any small projections like diminutive horns; such as exist on the hyoid bone—in addition to the two cornua, or horns. There are also cornicula of the larynx; the horns or cornicula of the hyoid; also the corniculum or horn of the thyroid. They hold the proper edges of the cords for their pyramidal office.

Correlation—The muscle autonomies, which have already done their part automatically, are brought into a higher state of activity by the direction of the mind, through the power of the will; hence, a mental attribute.—In Vocal Art-Science, refers to the macroscopic anatomical and physiological combination of automatic movements, as when one watches the lower lip in stammering and stuttering; while correlation refers to the operation of higher vibrations, as of the mind, with reference to the action of the upper lip when each pyramid attached to each one of our senses correlates.

Cortex—(Latin, bark, or outer covering of plants). An outer rind on any tissue or structure of the animal or human frame. (Adjective, cortical, from genitive *corticis*.) In Vocal Art-Science, the outer covering of the brain is meant.

Cricoid (Cartilage)—(Greek, *krikos*, ring; *eidos*, form.) One of the cartilages of the larynx. It is a ring of gristle, forming the top of the trachea, or wind-pipe. It is the concentrator of the energy of the voice; the immovable base of the momentic unit of the human mechanism.

Crura—(Plural of *crus*, Latin for leg). Term in anatomy applied to some parts of the body from their resemblance to a leg or root.

Cusp—A conoidal disc-shaped membrane with its apex slightly off centre; Tympanum or ear-drum.

Cuspoidal laryngeal halves—The two halves of the larynx formed by the four vocal cords and the ventricle contained between them; so named because they are hemispherical in plane and cuspoidal in vertical elevation.

Cyclones—(From Greek verb, to whirl). In Vocal Art-Science, refers to the whirling of the air-currents made by the breath passing through the several vocal apertures and avenues, in the formation of voice.

Deglutition—The act of swallowing.

Depressor Albii Inferioris—The muscle which depresses the lower lip.

Dexter—Pertaining to the right hand or right side; right, as opposed to left.

Diaphragm—Also called midriff; the dome-like musculo-membranous partition which separates the thoracic from the abdominal cavity in mammals.

In Vocal Art-Science, used to designate the separation of the Pneumatic from the Dynamic unit. From its nerve-supply it is found that the motor fibres act only with the abdominal unit, consequently it will be best understood that the action of the diaphragm is to grasp the entire contents of the abdomen, as a piston-rod does the contents of a cylinder.

The author has made over 6,000 X-ray examinations of human diaphragms, which have led to the discovery of this vital functioning of the diaphragm in respiration for song and speech.

Differential—Discriminating; differing in amount or size.

Diplophonia—Double voice—acute and grave sounds; a term proposed by the author as more expressive than Vox Convulsiva.

Dome—The hollow space back of the nose, existing between the choanæ and the soft palate. Post-nasal pyramid; the fourth pyramid of 3, 4, 5.

Dorsal Vertebræ—The vertebræ (or bones of the spine). Consist of several sections: 1st, cervical (neck); 2d, dorsal (back); 3d, lumbar (waist region), etc. Dorsal is derived from Latin *dorsum*, the back.

Dyspnœa—Difficulty of breathing, as in asthma.

Efferent—Conveying or leading outward; as distinguished from *afferent*, conveying inward. Used in connection with nerves and vessels of the body.

Empiricist (Empirical)—One who relies upon personal experience, rather than upon scientific knowledge. Experience is apt to degenerate into a vulgar and presumptuous "empiricism."

Energia—Another name for energy.

Epiglottis—A lamella, or thin plate of cartilage, placed in front of the superior opening of the larynx, and at ordinary times projecting upward immediately behind the base of the tongue. During the act of deglutition, or swallowing, it is carried downward and backward, so as to cover and protect the entrance to the larynx.

Epiglottisation—The determination of the position of the epiglottis, by an examination with the laryngoscope.

Equilibrium—That state or condition of a body in which all forces acting upon it balance one another. The force or resultant tending to move such a body is equal to zero.

Esophagus—The tube which conveys food and drink from the mouth into the stomach.

Evolute—In mathematics, a curve which is the focus of the centre of curvature of another curve, or the envelope of the normals to the latter. In Vocal Art-Science is a place back of the soft palate where the sounds of the voice are first made and carried to the inner ear, in contradistinction from the final vocal sounds heard by the outer ear.

Expression of force—Mutual action of the two sides of a right triangle, resulting in either a decrease or increase in the size of the hypothenuse. For instance, in the pyramidal organs of the body, the right triangle is the basic triangle, and by causing the sides to come closer together there is an emission of energy, while the reverse action results in the energy being consumed.

Falsetto—An unsuccessful attempt to combine a true fundamental of the vocal cords with an overtone out of balance, so that the overtone predominates by its intensity. A frequent phenomenon about the age of puberty, by some called "breaking" of the voice. An attempt to registrate octaves without correct balance of fundamental with overtone.

Fauces (plural)—Back part of the mouth, terminated by the pharynx and larynx.

Fibrinous—Relating to fibrin, the coagulating element of the blood; and also of inflammation.

Fibroma—A fibrous tumor; a tumor composed largely of fibrous, or connective, tissue.

Free nodal edges—Nodes formed on the edge of a vibrating body; due to the conditions of stress, torsion and recoil, and not to the fact that the body is brought into contact with the vibrating edge.

Fundamental (Tone)—The tone made by the *true* vocal cords, distinguished from vocal tones whose sonority is affected by means of the false vocal cords, tongue, palate, and other portions of the vocal mechanism, in creating overtones to balance the fundamental. In Vocal Art-Science it is believed every fundamental is accompanied by overtones made in the seven tone-forming spaces with which it must balance in power, resonance and pitch, in consonance and harmony; in correlation and coördination; also sympathetically, synchronously and automatically, if perfect. A perfect fundamental is at-one-ment of all these processes. A true fundamental vocal tone is produced only on inspiration, hence impossible on expiratory voice-production except as stated above. Tone produced on inspiration will give the poise of breath for vocalization.

Gamut—The musical scale; a word now almost obsolete. According to Brachet, Guy of Arezzo (A. D. 990) used to end the series of seven notes of the musical scale with the Greek G—gamma. The notes he named a, b, c, d, e, f, g—the last giving the name to the series. "Ut" is the Latin name for the first note of the scale, now called "Do."

Ganglion (plural *ganglia*)—A small mass of tissue, situated in the course of a nerve, and distinct from brain or spinal cord. The Sympathetic Nervous System consists of a series of ganglia, extending along both sides of the spinal (vertebral) column, connecting with all the other nerves of the body. Each ganglion is a distinct centre, giving off branches in four directions—superior, inferior, external, and internal. They are divided into the *cranial* ganglia, *cervical* ganglia, *thoracic* ganglia, etc. The connecting-up stations of the nerve-forces.

Gyration—The turning or whirling around a fixed centre or axis; spiral or rotary motion.

Hexalpha—The six-pointed star in Vocal Art-Science, to show the relationship of voice.

Hyo-Glossi (plural of *hyo-glossus*)—A flat, four-cornered muscle, connecting the hyoid bone with the tongue.

Hyoid Bone—The "tongue-bone"—a bony arch, giving support to the tongue, and attachment to numerous muscles of the neck. It consists of a body and two cornua (horns) projecting backwards, and two smaller cornua ascending from the angles between the body and the two larger cornua. It forms one of the chain of the seven true yokes that harness the voice.

Implastic—Incapable of being moulded into a desired form.

Infra-Laryngeal—Located below the larynx.

Infra-Red—Those vibrations below the red glow of color, in the spectrum, and invisible to the sense of sight.

Interference—In Vocal Art-Science, is where the adjusting moulder of tone-form is not true to nature, and obstructs the natural laws of tone-form in its evolution. In fact, any abnormal factor introduced to obstruct the laws of tone-form.

Intrinsic Muscles—Muscles within a cavity, or part of the body, as distinguished from extrinsic muscles, or those which are exterior to a part or locality.

Kinesis—The force which imparts motion to bodies, or influences motion already imparted to them.

Kinetoscope—A machine invented by Thomas A. Edison, which displays pictures (taken by the kinetograph) so rapidly that they all seem to be one scene, in motion. Vulgarly known as "Moving Pictures."

Klang-Tint—The so-called color, or tint, of a sound-form. It is an analogy of light and sound; e. g., power and number; resonance and form; pitch and color.

Laryngologist—One proficient in the art and science of laryngoscopy, or the examination of the larynx, and the proper treatment of its diseases, as well as its hygienic care and exercise.

Laryngo-Pharyngeal—Pertaining to that part of the throat located at the junction of the larynx with the pharynx.

Larynx—The wind-pipe, the voice-box. It is built up of the cricoid cartilage above the trachea, and contains the arytenoid cartilages and vocal ligaments—pyramids and prisms (or shelves), terminating in the glottis and epiglottis. It is the principal organ of voice. In Vocal Art-Science, it is the organ for momentum of voice.

Ligament—A short band of inelastic tissue, for binding bony parts together.

Macroscopic—(Greek, *makros*, large, long). Pertaining to the larger view of the universe; or gross parts seen with the unaided eye.

Meckel's Ganglion—The spheno-palatine ganglion, the largest of the cranial ganglia.

Momentic—Pertaining to momentum, the force possessed by matter in motion. Refers to the momentum or motion of air-columns, created in the ventricle between the true and false cords, as they operate as pyramids to produce vocal sounds. Pyramids creating prismatic relationship.

Muscle-Set—A group or set of muscles which act in such harmony, or unity, as to form an autonomy.

Nasal-Complex—This is represented by the choanæ or spaces surrounding the turbinate bones. A certain amount of resonance, reflection and refraction of sound is added to the voice by the deflection of the column of air into this resonantic part of the vocal mechanism. The removal of the turbinate bones which have hypertrophied or grown abnormally from one side of the nasal cavity, has been known to add five or six tones to the range of a singer, and also to materially assist the resonance of the singing and speaking voice.

Nasal Duct—A small passage in the superior maxillary (upper jaw) bone, and descending to the lower meatus (opening) of the nose; leading from the inside of lower eyelid and corner of eye to the lower portion of the middle turbinated bone.

Nasality—A disagreeable quality of voice. Not to be confounded with *nasal resonance*, a requirement of proper tone-making.

Nasal Resonance—In Vocal Art-Science, refers to that specific quality of voice that is dependent upon regulation of sound-cyclones, passing up back of nose, into choanæ due to the action of the soft palate.

Naso-Labial—Relating to the nose and lip; as, naso-labial line.

Neurasthenia—From the Greek, signifying a weakened condition of the nervous system; commonly called "nervous exhaustion."

Neuritis—Inflammation of the nerves. This may be general or circumscribed—confined to a part, the usual neuritis.

Neuron—A nerve-cell, with its fibrous attachments, considered as a unit of structure. A neuron has a form somewhat like an oyster (of microscopic dimensions), but with tentacles which contract, or touch and react upon associated fibres, in a manner to convey sensations through the body from some central nerve-point.

Nucleolus—Diminutive of NUCLEUS. In anatomy, one or two strongly refracting particles within the nucleus of a cell.

Nucleus—(From Latin, a small nut or kernel, from *nux*, *nucis*, a nut). In anatomy, the nucleus is the central part of the cell, from which development begins.

Occiput—(Latin, *ob caput*). The back part of the head; the part opposite to the front part, or sinciput.

Omentum—(Latin, *omen*, omen). The caul, mentioned in the Bible; a fold or reflexion of the peritoneum. There are two main folds, called the *lesser* omentum, which surrounds the liver and passes to the stomach, wraps and separates the genitals on the outside from the area enveloped by the greater omentum as a pyramid, to cover and protect the inner structures of the sexual poles, while the greater omentum covers the entire gross structures of the abdomen in the form of a funnel pyramid, with its point downward, while its base, turned upward, presents the supporting leaves of the diaphragm for the lungs; and the *greater* omentum, which surrounds the stomach and returns to the transverse colon, etc.

Optophone—A mechanism by which light is thrown, by means of a prism, upon printed letters and then reflected on selenium, which, in turn, gives a responsive sound carried to the ear of the blind by means of a telephone.

Orbicularis Oris—The muscle which closes the mouth, entirely or in part, as in the formation of vowel-sounds. A typical controller of lips.

Oriento-panæsthetization—Is the peculiar summation and perception of the physico-mental coördinated and correlated faculties without physical and emotional powers in pure vocal tone-expression at the apex of our triangle of efficiency.

Oscillograph—An electro-magnetic machine constructed by Professor Pupin, which is able under electric stimulus to measure the finest electrical vibrations.

Overtones—Harmonics, or upper partials. In Vocal Art-Science, the terms refers to tones whose vibrations are in excess of those of the fundamental, yet that harmonize with it, that embellish its quality, and, finally, when they exist in full complement and balance, insure perfect tone. If one attempts to speak on inspired breath, it will at once be noted that there is lacking a richness of intonation—caused by the absence of the overtones.

Palate (Soft)—(Latin, *velum palati*). The posterior limit of the Palate (Hard), the upper wall of the mouth.

Palato-Glossal—Relating to the tongue and palate.

Palato-Pharyngeal—Relating to the palate and pharynx.

Papilloma—A condition of the submucous tissues of the tongue, rendered tough, brawny, coarsely papillary, and fissured, at times. General cause, smoking.

Partials—Related to overtones; harmonics.

Penetralis (Vocal)—Penetrating. All voice is positive. Its action is directly, progressively forward.

Pharyngo-Nasal—Relating to the pharynx and nose.

Pharynx—The dilated commencement of the gullet.

Phonation—The production of sound; voice.

Phonometer—An instrument designed to ascertain the number of vibrations of a given sound in a given interval of time. Vocal Art-Science, by its system of measurements, is able to establish a basis, through measurements, of the capacity or content of every voice.

Pituitary Body—A small, reddish-gray, ductless gland, located in the centre of the floor of the brain. It is divided into an anterior and a posterior lobe, and occupies the *sella turcica* ("Turkish saddle") of the sphenoid bone. Formerly called the pituitary *gland*, from the erroneous belief that it discharged mucus into the nostrils. Vocal Art-Science regards the Pituitary Body as the Balancer of brain and body.

Polarity—Having two poles. A magnet which has two poles is said to possess polarity.

Polarization—A term applied by Vocal Art-Science to the phenomenon of the power inherent in the tongue, which, owing to its position relative to the three vocal cavities (the Momentic, Vocalic and Resonantic) and its possession of a positive and negative pole (i. e., the base and tip), tends to act as a concentrator, director and assimilator of vocal sound-cyclones; the waves of the various units assuming fields very similar to those about an electro-magnet, and from here are projected into space, as a perfected tone; the application being more closely related to that of the electro-magnet than to the polarization of light. If polarization has a tendency to establish a wrong interpretation of the above processes, the coined term *polanization* may be substituted.

Polarized—Having polarization, or affected by polarization.

Pseudoscopist—One who copies or utilizes another man's ideas. One who has not had time, by reason of his attention to his own duties, to enroll such ideas in the Hall of Fame.

Raphe—A seam, or longitudinal line, dividing anything into two portions or areas; as the raphe of the medulla oblongata, etc.

Reflection—The change in direction experienced by a wave of light, sound or heat, when it strikes a surface and is thrown back into the same space from which it came.

Registration—At definite points of the scale in natural production the resonators are correlated in the progression of the tone. The so-called break, which acquires a registration at different points of the scale (as is generally supposed) is entirely unnecessary in correct use of voice. At these points a new octave of resonance is coördinated and correlated.

Resonator—Hollow receptacle so formed as to correspond sympathetically to one particular sound. Also used to measure the volume of sound. The mouth is a resonator; the nose, also.

Rhomboid—The rhomboid muscles, major and minor, extend from the fifth cervical to the fifth dorsal; pull scapula upward, inward and backward or hold it firm against the downward or forward pulling of any of the intersecting muscles. Therefore, they polarize and balance the neck to spine, shoulder to neck by scapula and arm, hence it is true that sympathetic vibrations of voice are carried and sensed in the very knuckles and finger-tips of Caruso, by his London physician.

Rima—A cleft, or rim; as the *rima glottidis*, rim of the glottis.

Rotating Mirrors—A series of mirrors placed on a revolving stand, so that they catch the reflected light-vibrations, used in making graphic records of sound as devised by König. It is not a good analytical method.

Ruga (plural, *ruga*)—Latin for wrinkle. Hence, ridges, as seen in certain mucous membranes, e. g., the stomach.

Rumblic—Relating to a low, rumbling noise. Made by a trilling or twirling of the tip of the tongue, in sympathetic movement or vibration with the tip of the nose, and the vomer or partition-bone of the nasal resonating space. It is usually heard in the Continental languages, when the letter "r" is pronounced. In this country it is not so used—in fact, in certain parts of the United States, this rugged little consonant is, for some reason, entirely ignored, "are" being pronounced *ah*, and "sword," *sawed*.

It refers especially to the tongue's action in holding its basic pyramid so as to produce a continuous sympathetic nasal resonance on the letter "M," while the tip of the tongue is synchronously vibrated in the rolling of the letter "R," as in the word itself, "rumblic."

Sector—A part of a circle, bounded by two radii and the included arc.

Segmentation—The act or process of dividing, or separating.

Sequence of Overtone Scale—The average voice covers a range of three octaves: first, one octave of itself; second, a segmented octave; and third, an undertone octave. Each octave contains two whole tones and a half-tone, followed by three whole tones and a half-tone.

This sequence makes up the diatonic scale. Each tone has its counterpart or overtone above and its undertone below. A tone can never be properly balanced without its overtone. Each step of the diatonic or chromatic scale has its own complement in its overtone and undertone, dependent upon its power, which is developed according to 3, 4, 5. The overtone is due to segmentation of the entire vocal apparatus that produces a sympathetic higher resonance tone with its fundamental tone always in harmony, consonance and entrain.

Sinister—Pertaining to the left hand or left side; left, as opposed to right.

Sinus—A hollow place. In the human body there are the antral sinus; the frontal sinus; the mastoidal sinus; the sphenoidal sinus; etc. These sinuses, though hollow spaces, are not resonators, for their orifices will not allow of resonance; they are vocal shock-absorbers.

Sonantic—Relating to vibrations producing definite tone, as distinct from mere aspirates.

Sound-Form—That which is made for the purpose of collecting and reflecting sound. Any device that will accomplish the purpose.

Spectrum Analysis—Determination of the elementary constituents of a body by a study of their spectra.

Sphincteric Aperture—An opening controlled by a sphincter—a muscle with power to contract and close an aperture, or opening. (The lower parts of the body are controlled by sphincters: *sphincter ani.*)

Spiral Tone-Ray—There are two columns of air, one from the right and the other from the left of the lungs, sent up through the bronchial tubes to the trachea. The right column is stronger and one-twelfth larger in every way than the left, because the right side of the lung is composed of three lobes, while the left is composed of but two—the heart taking the place of the third lobe. The vowel-producing air-column is centrifugal or polarized to the right; the companion air-column is centripetal, and is for consonant production.

The trachea is shaped like a spiral cone. These two columns of air forced up helically through the trachea, whirling around like the spire of a winding staircase; ever increasing in concentrating power elements, that are practically vocal by the time they reach the cord, and this vertical force is the source of energy supplied to furnish vocal momentum, and vibrate the true vocal cord.

Spiritus Asper; Spiritus Lenis—In Vocal Art-Science, this is the vital residual *breath*—ever generated as long as life lasts. The first word of the combination, "spiritus," signifies breath; the second, "asper," means rough; "lenis," gentle.

Sub-chambers—In Vocal Art-Science, the unchangeable, bony cavities with special orifices. The stationary unalterable openings which are attached, as accessories and auxiliaries of sound-phenomena, to the nose—such as the antral and frontal sinuses.

Supra-Laryngeal—Above the larynx.

Synæsthetization—According to Vocal Art-Science, a term used to designate the existence of a coördinated, correlated physico-mental process on one hand and a physical power on the other.

Syrinx—The inferior larynx, a modification of the trachea where it joins the bronchi; an organ peculiar to songbirds, their organ of voice.

Telegraphone—An instrument recently perfected by Poulsson for magnetically recording and reproducing telephone conversation.

Tempered Scale—The system of compromises whereby (in such instruments as the piano and organ) the "twelve tones in an octave are made to do duty in place of about forty-eight which would be necessary to *perfect* intonation in all keys." (Mathews.) In Vocal Art-Science, refers to the correct cosmic impression of the sounds of a scale of tones on the tympanum of the ear, which is a tented pyramidal drum.

Template—A mold or pattern used by machinists, etc.

Tensor Palati—The tensor muscle of the palate.

Thyroid Body—A soft, reddish and highly vascular body situated over the trachea, consisting of two lateral lobes, united at their lower ends by a transverse portion called the isthmus. It forms a rounded projection upon the trachea and larynx.

Thyroid Cartilage (briefly termed "thyroid")—Composed of two flat, lateral plates, continuous in front, forming a narrow angle like the letter "V." In the male it is called the "Adam's apple."

Tonality—Correctness of pitch—key-relationship; as when a melody or passage in harmony is said to be correctly related to the key. Also refers to production of sounds "in tune, or out of tune"; and, again, to that quality

wherein a singer or instrumentalist (violinist) is said to produce pure or impure tones, with relation to key.

Tonsils—The round glands situated between the folds of the "velum palati." Also Adenoids.

Tonsillotomy—The operation for removing a part, or whole, of the tonsils, by cutting them out with a knife or tonsillotome. From the phonetic (singer's) standpoint, little understood by the medical profession; because of which, often many cases of "monotone" voice have been inflicted upon the persons injudiciously and improperly operated upon. Further injuries to perfect voice have been due to cutting those parts that produce *intermediate* vowels.

Trachea—The wind-pipe. Beginning above the larnyx, it extends below to join, or divide into, the two main bronchi (bronchial tubes). The trachea is nearly everywhere connected with loose areolar tissue, abounding in elastic fibres, and readily moves on the surrounding parts; a part of the automatic movement in voice-production, under proper training, as well as in other unconscious movements of the throat in swallowing, etc.

Tracheostenosis—Contracting or narrowing of the trachea.

Tracheotomy—The operation whereby the trachea is opened, in inflammatory conditions (croup, etc.), in order to admit air to the lungs; or in other cases of stoppage of the air-passage.

Transmission—The act of carrying from one point to another; carrying through or over a body.

Tremolo—Reiteration of vocal sounds, irregularly, with depressed pitch. Generally a lowered vitality and physical depression accompanies this phenomenon.

Tympanum—A drum. Technically, the drum or middle-ear chamber. An irregular cavity in the petrous part of the temporal bone. It lies between the inner end of the external auditory canal and the labyrinth. It is a hard, bony chamber, and across its outer opening is stretched a thin, semitransparent membrane—the membrana tympani—which forms the inner end of the external auditory opening, or meatus. Vocal Art-Science holds that the tympanum's construction determines the law of Kinesis of sound-phenomena, in human beings, because it is a typical receiver of Pyramido-prismatic sound.

Ultra-Violet—Those vibrations of light, beyond the violet (visible) rays, and that are invisible to the sense of sight. The ultra-violet is also the controller of all wireless wave-music phenomena, superseding audion.

Uvula—The soft, grape-like end of the soft palate. It hangs from the hard palate and incorporates all the fasciculi (strands of muscle) that come from above it, with one common raphe; so that their "spliced" and intermingled ends resemble a grape (uvula being the diminutive of the Latin *uva*, a grape).

Vacuole—A cavity, chiefly formed in the interior mass of protoplasm, by filtering into it drops of water. The term is used, however, to signify a small vacuum, or empty space.

Velum Palati—The veil of the palate; the soft palate.

Ventricle—Diminutive of *venter* (Latin for stomach); a small stomach. Used to describe any cavity in the human body, smaller than the stomach; as the several ventricles of the brain, and the larger ventricles of the heart. The small cavity between the true and false vocal cords is called a ventricle. In Vocal Art-Science, the ventricle of the larynx, between the true and false vocal cords, furnishes the chief means of showing that the voice is the result of the Pyramido-Prismo-Conico-Helico-Cuspoidal-Spherical relationship.

Vertebra (pl. Vertebræ)—Any joint of the spinal column. The several series of vertebræ are (1) the *cervical* (neck)—seven; (2) the *dorsal* (back)—twelve; (3) the *lumbar* (loins)—five; the *sacral* (from the part used in ancient

sacrifices), a firmly united, compact mass, of five segments; and the *coccyx*, a caudal (tail-like) reminiscence of lower orders.

Vibrato—A strong, rapid, vibrating quality of tone, generally due to over-excitement. Often sharp as regards pitch.

Vocal Efficiency—Effectiveness of the methods of Vocal Art-Science in developing and correlating the physical, mental and psychical faculties into the phenomena of vocal perfection.

Vocal Folds (Cords)—The ultimate organ of phonation—*voice*. Located within the larynx, these folds, when closed, shut off the air-passage *entirely*, the slit between them forming the *glottis*. Both cords are pyramids, symmetrically placed and double. With them, equally doubled and symmetrically placed, is the cartilage of Santorini. Also, the bony arytenoid cartilages, in conico-helicoidal curves, forming absolutely hollow pyramids—double—and symmetrically placed; acted upon in their hollow pyramidal forms, by means of the air from the concentrating, bony cricoid, by directing the thyro-cricoid angle, with its elastic ligamentous, regulating notch.

Vocatorium—Vocalion. Vocatorium, the universal place of vocal tone; the vocal-former. Vocalion, the vocal instrument.

Vocometer—A measurer of *voice*, as distinct from *Phonometer*, a measurer of *sound*.

Voice-Synthesis—The assembling of analogous parts of voice.

Vomer (Bone)—A small, thin bone in the median line of nostril, forming the posterior and principal portion of the partition between the nostrils. The bone is so named because, in man, it bears some appearance to a plowshare (Latin, *vomer*, plowshare).

Vowel—A vowel is the beginning and end of voice; it is the thread of the stream, the blood of the heart, the very soul of the voice, the core of the consonant. It begins in silence and evolutes into the sound of voice. It is the tone formed by the ventricles at the glottis, or first sphincter, into momentum of sound developed from the force of compressed air.

A vowel is a polarized vocal-column or voice-stream of air, which may be described as "a stream, always going forward." If it were not for the forward direction, we should have no voice. The vowel-stream is centrifugal in its action.

Vox Convulsiva—Double voice; acute and grave sounds, involuntarily produced in succession.

Zygomatic—(From Greek *zugos*, a yoke). The zygomatic process is a thin, narrow projection of bone, bounding the squamous (scale-like) portion of the temporal bone at its base. It forms the upper boundary of the cheek.